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FIELD EXPERIMENTS IN SPRAYING APPLE ORCHARDS IN 1913 AND 1914

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Contents of Bulletin No. 206

PAGE

Introduction 429
Spraying Experiments in 1913 at Neoga, Cumberland County..... 432
Spraying Experiments in 1914 at Neoga, Cumberland County..... 441
Spraying Experiments in 1913 at Flora, Clay County..... 449
Spraying Experiments in 1913 at Griggsville, Pike County..... 458
Spraying Experiments in 1914 at Griggsville, Pike County..... 472

General Summary

- summary of data..... 490
- incidental observations 504
- recommendations 505

FIELD EXPERIMENTS IN SPRAYING APPLE ORCHARDS IN 1913 AND 1914

INTRODUCTION

By B. S. PICKETT, Assistant Chief in Pomology

Objects of Field Experiments in Spraying Apple Orchards in 1913 and 1914

In view of the exhaustive investigations already made by the Department of Horticulture in spraying for the control of insects and diseases attacking the apple,[1] it seems advisable to explain the necessity for further experiments in spraying.

No single operation in apple growing yields such immediate and large returns for the money and time invested as spraying. In fact, it is a rare season in Illinois when unsprayed apples are marketable, except for cider and evaporating purposes. The extreme importance of the operation, in itself, is therefore sufficient cause for unremitting experimental efforts to make it more and more effective and less and less costly. New sprays are constantly being placed on the market by enterprising firms dealing in spraying materials. New forms of standard insecticides and fungicides, whose merits and faults call for investigation, are introduced annually. Some of the effects of the standard sprays are not yet fully understood, as, for example, Bordeaux russet, yellowing of the leaves following the use of Bordeaux, and lime-sulfur burn. The efficiency of the standard sprays varies in different seasons, and only the cumulative data of many years of experimental work seem likely to afford records sufficient to permit a conclusive coordination between climatic conditions and the effects of the sprays. Methods of application, including amounts, pressures, character of agitation, and machinery, are not yet perfect; each season's experiments show a need for further tests along these lines.

The field experiments in spraying in 1913 and 1914 included further tests of the effectiveness and relative values of the standard sprays on the control of fungi and insects affecting the apple crop, of several makes and brands of arsenate of lead, certain new and proprietary fungicides, several methods of preparing and using copper ferrocyanide, the effects of varying quantities, pressures, and nozzle openings, the use of Bordeaux for some applications and lime sulfur for the remaining applications in the spray schedule of the same season, the effects of certain special spray practices on the control of codling moth, and the efficiencies of various strengths of lime sulfur.

[1] The details of these investigations are contained in Bulletins 98, 106, 114, 117, 118, 135, and 185, and popularized in Circulars 112, 120, 136, 137, 159, 160, 171, and 172.

ORGANIZATION

The experimental orchards were located at Neoga in Cumberland county, at Flora in Clay county, and at Griggsville in Pike county. O. S. Watkins conducted the experiments at Neoga, W. A. Ruth, those at Flora, and A. J. Gunderson, those at Griggsville.

STANDARD SPRAYS: FORMULAS AND PREPARATION

Except where noted in connection with the individual experiments, the standard sprays used were prepared according to the following formulas and directions:

Bordeaux.—Eight pounds copper sulfate, 8 pounds freshly slaked lump lime, 100 gallons water. The mixture was prepared by dissolving the copper sulfate in half the total quantity of water used, and mixing the slaked lime with the other half. The diluted solution and the diluted mixture of lime were then poured simultaneously thru a sieve, either into the mixing tank or directly into the spray tank.

Lime Sulfur, Commercial, for Summer Sprays.—Eight pounds of sulfur in 100 gallons of spray (3 gallons commercial concentrated lime sulfur to 97 gallons of water, or 3 gallons commercial concentrated lime sulfur in 100 gallons of the dilute summer spray).

Lime Sulfur, Commercial, for Dormant Spray.—Twenty-nine to 30 pounds of sulfur in 100 gallons of spray (11 gallons commercial concentrated lime sulfur to 89 gallons of water, or 11 gallons commercial concentrated lime sulfur in 100 gallons of spray).

Lime Sulfur, Homemade, for Summer Sprays.—Eight pounds of sulfur in 100 gallons of spray (5½ gallons stock solution homemade lime sulfur to 94½ gallons of water, or 5½ gallons stock solution homemade lime sulfur in 100 gallons of spray).

Lime Sulfur, Homemade, for Dormant Spray.—Twenty-nine pounds of sulfur in 100 gallons of spray (20 gallons stock solution homemade lime sulfur to 80 gallons of water, or 20 gallons stock solution homemade lime sulfur in 100 gallons of spray).

Stock Solution, Homemade Lime Sulfur.—One hundred pounds of sulfur, 50 pounds of lime, water to make 66 gallons.[1] Homemade lime sulfur was prepared by placing in a large kettle 15 gallons of water and 50 pounds of good lime, free from air-slaked particles. When the lime was slaking vigorously, 100 pounds of powdered sulfur was poured in and mixed thoroly with the lime. Sufficient water was added gradually to prevent the lime from drying out during the process of slaking. As soon as the lime was thoroly slaked and the sulfur thoroly mixed, enough water was added to bring the total volume to 66 gallons or a little more. Boiling was continued for 30 to 45 minutes, water being added from time to time to keep the volume at 66 gallons. By following this method it was found possible to get the

[1]Illinois formula.

maximum amount of sulfur into solution. The boiling was done in large iron kettles heated over simple outdoor fireplaces or in 75-gallon feed cookers.

Arsenate of Lead.—Four pounds of paste arsenate of lead in 100 gallons of water, Bordeaux, or lime sulfur. The arsenate of lead was worked up with a small quantity of water into a mixture that would pour readily and mix evenly with the water or fungicide when subjected to the action of the agitator in the spray tank.

TIMES OF APPLICATION

The various applications are designated as follows: dormant-tree spray, first, second, third, and fourth summer sprays, and extra sprays. The dormant-tree, or winter, spray is applied between the falling of the leaves in autumn and the swelling of the buds in spring. Its primary function is the destruction of scale insects. The first summer spray is applied between the bursting of the cluster buds and the opening of the blossom buds. The application of the second summer spray is begun as soon as most of the petals have fallen. It is followed in about ten days by the third application. The time of the later applications varies, depending on the purposes for which they are given. The exact dates of the applications in these experiments are given with each report.

RECORDS

The records of these experiments include data of insect and fungous attacks on both fruit and foliage and of the amount and character of spray injury, percentages of the various grades of fruit, and observations of prevailing conditions of weather. Dropped apples were examined at intervals thruout the season, and at harvesting time both dropped and picked apples were examined for evidences of disease and insect injury, the observations being tabulated for comparative study. Frequent observations of the effectiveness of the sprays in controlling insects and fungi attacking the foliage, or of their being in themselves the cause of injury, were also recorded. Weather observations were recorded in the form of daily maximum and minimum temperatures, temperatures at stated hours, rainfall, cloudiness, and direction of the wind.

ARRANGEMENT OF SUBJECT MATTER

The method of presenting the data obtained in the spraying experiments in 1913 and 1914 is similar to that used in Bulletin 185, which gives the data recorded during the years 1909-12. A yearly report is made by each experimenter, giving at length the plan of the experiment, conditions, methods, data, and summary of results. A general summary of all the results for the two years follows. Finally, a series of spraying recommendations is given.

SPRAYING EXPERIMENTS IN 1913 AT NEOGA, CUMBERLAND COUNTY

BY O. S. WATKINS, ASSOCIATE IN HORTICULTURAL CHEMISTRY

OBJECTS

The chief objects of the investigations at Neoga in 1913 were to determine (1) the comparative values of several brands of arsenate of lead, alone and in combination with lime sulfur; (2) the value of a fourth summer spray for the control of second-brood codling moth; and (3) the relation of pressure to Bordeaux injury.

LOCATION AND DESCRIPTION OF ORCHARD

An orchard owned by H. A. Aldrich and Company and situated one-half mile west of the railroad station at Neoga was chosen for these experiments. The 120 acres comprizing the orchard were planted to several different varieties of apples, thereby affording ideal pollinizing conditions. Since the planting of the orchard in 1900, it had received excellent care; hence the trees were in a very healthy condition. Seven acres of Ben Davis trees and five acres of Jonathan trees were selected for experimental purposes. These tracts were divided into plats of four to ten trees each, the various plats being treated differently. Scattered among the plats were certain trees which were not sprayed, and which were reserved for comparison with the sprayed trees. The arrangement of the plats is shown in Fig. 1.

APPARATUS AND MATERIALS

The sprays were prepared according to the methods described on pages 430 and 431. They were applied with a Friend power outfit; unless otherwise stated, a pressure of about 135 pounds was used. A single Friend angle nozzle was used on the tower pole, and a Gould double Mistry, attached to an angle Y, was used on the ground pole.

The brands of arsenate of lead tested were Corona dry, Vreeland powdered, and Grasselli, Hemingway, Sherwin-Williams, and Thomsen pastes.

WEATHER CONDITIONS

The weather conditions for 1913 were far from normal. Early in May a drouth began which continued until late in August. The combined rainfall of May, June, July, and the first three weeks in August was less than four inches, and at no time was there as much

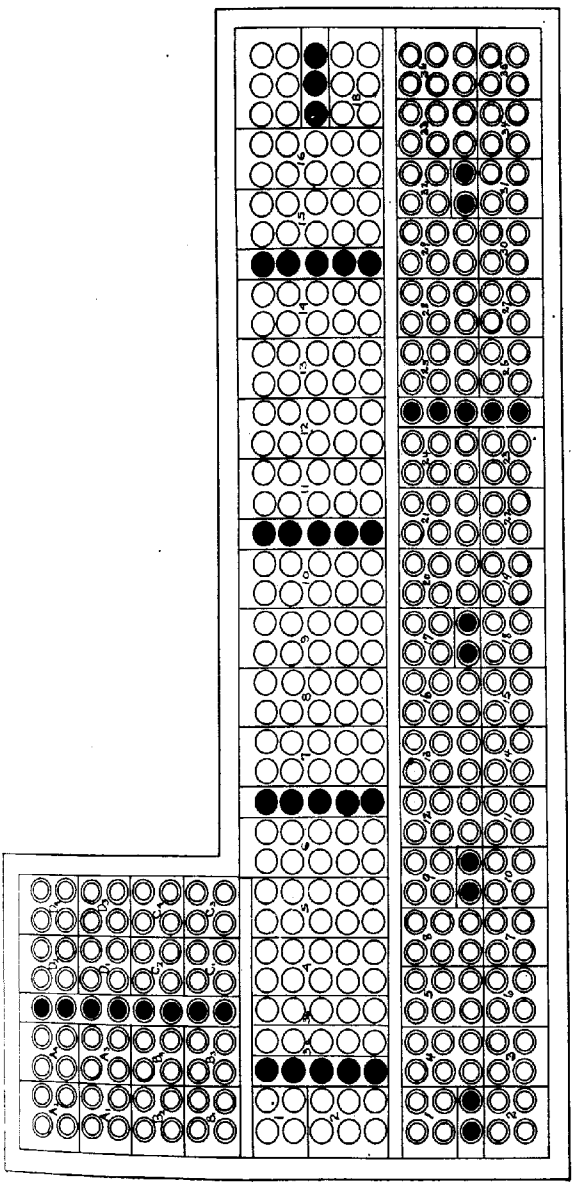


FIG. 1.—PLAN OF PLATS IN ORCHARD OF H. A. ALDRICH AND COMPANY, NEOGA, 1913

as one-half inch in a single rain. The orchard was, therefore, in a very dry condition all summer. Even the spray pond was exhausted during the third application, and water for the remainder of this application and for all of the fourth was hauled from a well in town. On five days in June, eight days in July, seven days in August, and two days in September, the temperature exceeded 100° F. During this dry season no fungous diseases developed; hence the data collected relate chiefly to codling-moth injury.

The trees came into bloom early in May. The bloom of the Jonathan trees was very heavy, but that of the Ben Davis trees was light and scattering. The weather was excellent for pollination, and a very good set of fruit resulted wherever there was good bloom.

SPRAY DATES

The entire orchard was given a winter application of lime sulfur early in April. Three or four summer applications were made upon or near the following dates: April 24, May 12, May 22, and July 8.

TESTS OF VARIOUS BRANDS OF ARSENATE OF LEAD ALONE AND IN COMBINATION WITH LIME SULFUR

These tests were made with the Ben Davis variety on plats of four to six trees each. The plats were treated as shown in Tables 1 and 2. In every case, applications were made on the same day and under conditions as nearly alike as possible.

EFFECT ON FOLIAGE

Little difference was noticed in the appearance of the foliage given the various treatments. As late as September it was impossible to distinguish the unsprayed trees from the sprayed, except by close inspection. Where arsenate of lead alone was used, no spray injury of any kind appeared. Plat 28, sprayed with Vreeland powdered arsenate of lead and lime sulfur, showed a small amount of leaf-burning shortly after the third application, but this resulted in no serious injury to the foliage.

EFFECT ON FRUIT

The fruit from the plats sprayed with arsenate of lead without a fungicide was picked October 14, with the results presented in Table 1. Less than half a crop was harvested; consequently the records obtained may not be considered entirely conclusive. A very severe infestation of codling moth was present; in fact the unsprayed trees showed nearly 100-percent injury. In both the sprayed and the unsprayed plats, the smaller the crop, the greater was the injury. In

the plat sprayed with Grasselli arsenate of lead, where less than a bushel of apples per tree was produced, the infestation was severe. The best control was shown in the plat sprayed with Sherwin-Williams arsenate of lead, where the trees yielded considerably more fruit.

TABLE 1.—EFFECTS OF DIFFERENT ARSENATES OF LEAD USED ALONE, ON BEN DAVIS APPLES, IN THE EXPERIMENTS AT NEOGA, 1913

Plat	Treatment	Applications	Picked apples				
			Total No.	Percentage affected by—			
				Codling moth			Russet
				Calyx	Side	Total	
19	4-100 Grasselli arsenate of lead	1, 2, 3	528	3	63	66	0
21	4-100 Sherwin-Williams arsenate of lead	1, 2, 3	2310	4	30	34	0
23	2-100 Corona dry arsenate of lead	1, 2, 3	2096	1	43	44	0
Check	No treatment	None	416	18	80	98	0

Most of the trees sprayed with the various arsenates of lead in combination with lime sulfur produced a half crop or more. This was picked October 14; the results of the examinations are shown in Table 2. The trees in these plats, like those sprayed with arsenate of lead alone, showed a large amount of codling-moth injury; here, also, the degree of injury tended to vary with the yield of fruit. Plat 25, sprayed with 4-100 Corona dry arsenate of lead, and having the largest yield of fruit, showed the least injury from codling moth. Only one plat, that receiving Vreeland powdered arsenate of lead, showed any russet; 9 percent of the fruit from that plat was sufficiently russeted to be graded with the culls.

TABLE 2.—EFFECTS OF DIFFERENT ARSENATES OF LEAD IN COMBINATION WITH LIME SULFUR, ON BEN DAVIS APPLES, IN THE EXPERIMENTS AT NEOGA, 1913

Plat	Treatment	Applications	Picked apples				
			Total No.	Percentage affected by—			
				Codling moth			Russet
				Calyx	Side	Total	
A_1	4-100 Grasselli arsenate of lead with lime sulfur	1, 2, 3	1530	5	45	50	0
24	2-100 Corona dry arsenate of lead with lime sulfur	1, 2, 3	2060	2	49	51	0
25	4-100 Corona dry arsenate of lead with lime sulfur	1, 2, 3	3571	2	38	40	0
26	4-100 Thomsen triplumbic arsenate of lead with lime sulfur	1, 2, 3	1064	5	56	61	0
27	4-100 Hemingway arsenate of lead with lime sulfur	1, 2, 3	1800	7	56	63	0
28	2-100 Vreeland powdered arsenate of lead with lime sulfur	1, 2, 3	2112	14	50	64	9
Check	No treatment	None	416	18	80	98	0

The results of this experiment, altho hardly consistent, somewhat favor the Grasselli paste and Corona dry arsenates of lead.

VALUE OF A FOURTH SUMMER SPRAY FOR SECOND-BROOD CODLING MOTH

It has been a question among growers whether the second-brood codling moth did sufficient injury to warrant a special application to prevent it. To determine the value of a fourth summer spray, applied early in July, at the proper time to check the attacks of second-brood codling moth, two plats of Ben Davis trees were sprayed as shown in Table 3. Commercial lime sulfur and Grasselli arsenate of lead paste were used.

In order to determine the effect of the spray upon an earlier ripening variety, experiments were also conducted on Jonathan apples, which mature two or three weeks earlier than Ben Davis. Valuable results were secured, for the fruit of this variety was picked before a third brood, which appeared very late in the season, began to work. The treatments for the Jonathan plats are shown in Table 4. Each plat was divided into two sections of five trees each; one section was sprayed three times and the other four times.

EFFECT ON FOLIAGE

No foliage injury of any kind appeared. On the Ben Davis trees the fourth application was visible thru the entire season. On the Jonathan plats, wherever Bordeaux arsenate of lead was used, the spray remained visible longer than where other sprays were applied.

EFFECT ON FRUIT

The Ben Davis plats produced a small crop, which was picked October 15, giving the results presented in Table 3. Here the benefits of the fourth application could not be determined, for a third brood of moths began infesting the apples early in October, upon which the application made in July exerted no influence. This late brood far outnumbered the first and second broods combined.

TABLE 3.—EFFECTS OF SPRAYING FOR SECOND-BROOD CODLING MOTH, ON BEN DAVIS APPLES, IN THE EXPERIMENTS AT NEOGA, 1913

Plat	Treatment	Applications	Picked apples			
			Total No.	Percentage affected by codling moth		
				Calyx	Side	Total
A_1	Lime sulfur arsenate of lead	1, 2, 3	1530	5	45	50
A_2	Lime sulfur arsenate of lead	1, 2, 3, 4	822	3	50	53
Check	No treatment	None	416	18	80	98

All the Jonathan plats produced a good crop. The fruit was picked September 23, and showed the results presented in Table 4. The fourth application reduced codling-moth infestation from 15 to 47 percent wherever used, thus demonstrating the effectiveness and value of this spray, especially for seasons like that of 1913, when the insect was present in such large numbers. In contrast to the Ben Davis plats, where the fruit was harvested after the appearance of a third brood, the fruit from the Jonathan plats showed the actual degree of control exercised by the sprays on the second brood. Quite a number of apples were cracked, probably as a result of rapid growth caused by the rains which fell just previous to the ripening of the fruit.

TABLE 4.—EFFECTS OF SPRAYING FOR SECOND-BROOD CODLING MOTH, ON JONATHAN APPLES, IN THE EXPERIMENTS AT NEOGA, 1913

Plat	Treatment	Applications	Picked apples				
			Total No.	Percentage affected by—			
				Codling moth			Cracking
				Calyx	Side	Total	
4	Copper ferrocyanide arsenate of lead	1, 2, 3	4234	3	29	32	3
	Copper ferrocyanide arsenate of lead	1, 2, 3, 4	2391	2	15	17	2
7	Lime sulfur arsenate of lead	1, 2, 3	3739	2	24	26	5
	Lime sulfur arsenate of lead	1, 2, 3, 4	5067	3	14	17	3
8	Lime sulfur arsenate of lead	1, 2					
	Bordeaux arsenate of lead	3	4050	2	25	27	4
	Lime sulfur arsenate of lead	1, 2					
	Bordeaux arsenate of lead	3, 4	4261	5	18	23	4
12	Bordeaux arsenate of lead	1, 2, 3	3474	7	27	34	12
	Bordeaux arsenate of lead	1, 2, 3, 4	5800	6	20	26	6
Check	No treatment	None	456	32	52	84	2

NOTE.—Four pounds of Grasselli arsenate of lead paste were added to each 100 gallons of spray. The copper ferrocyanide was made from 2 pounds of copper sulfate dissolved in 50 gallons of water, and 2 pounds of potassium ferrocyanide dissolved in another 50 gallons of water, poured together simultaneously. Commercial lime sulfur and 8-8-100 Bordeaux were used.

EFFECT OF PRESSURE ON BORDEAUX INJURY

In 1905 the Station began an investigation to determine the cause of injury following the use of Bordeaux. It had been noticed that whenever the material was applied with a hand outfit at a pressure of about 100 pounds, there was less injury than when it was applied with a power sprayer, which gave a higher pressure. To gain further information on this point, 8-8-4-100 Bordeaux arsenate of lead was applied to Jonathan trees at the pressures shown in Table 5.

EFFECT ON FOLIAGE

The trees sprayed with Bordeaux arsenate of lead at 125 pounds pressure developed no leaf-yellowing whatever. Those sprayed at a pressure higher than 125 pounds showed a small amount of this injury. In every case, the higher the pressure, the greater was the injury, altho in no plat was it serious. Heretofore Bordeaux injury had been accompanied by wet weather; this was not the case, however, in 1913.

EFFECT ON FRUIT

The trees in these plats yielded a very heavy crop of fruit, which was picked September 24, with the results presented in Table 5. The point of greatest interest in this table is in the russet column. Bordeaux applied at 125 pounds pressure caused no russeting whatever, while all pressures above that caused considerable injury. The extremely high pressures caused no more injury than the 160-pound pressure. The loss of fruit due to cracking was also greater where the higher pressures were used.

TABLE 5.—EFFECTS OF SPRAYING JONATHAN APPLES AT DIFFERENT PRESSURES WITH 8-8-4-100 BORDEAUX ARSENATE OF LEAD, IN THE EXPERIMENTS AT NEOGA, 1913

Plat	Spray pressure	Applications	Picked apples					
			Total No.	Percentage affected by—				
				Codling moth			Russet	Cracking
				Calyx	Side	Total		
9	160 lbs.	1, 2, 3	5192	1	16	17	5	15
	160 lbs.	1, 2, 3, 4	6450	4	14	18	13	14
10	190 lbs.	1, 2, 3	5939	1	20	21	9	10
	190 lbs.	1, 2, 3, 4	5550	1	16	17	9	16
11	225 lbs.	1, 2, 3	1007	4	26	30	7	17
	225 lbs.	1, 2, 3, 4	3157	2	20	22	9	22
12	125 lbs.	1, 2, 3	3474	7	27	34	0	12
	125 lbs.	1, 2, 3, 4	5800	6	20	26	0	6
Check	No treatment	None	416	18	80	98	0	0

The question as to the necessity of using 200 pounds pressure in spraying for codling moth is apt to come up in this connection. These results show that 225 pounds pressure controlled codling moth very little more efficiently than 125 pounds.

Interesting facts not shown in the table were brought to light by an examination of the dropped apples. Very little codling-moth injury appeared earlier than August 1, even upon the check trees. From August 1 until harvest time the number of drops injured by

codling moth rapidly increased. Practically all dropped apples which were picked up under check trees during August and September, showed codling-moth injury. In some of them as many as eight worm-holes appeared in a single apple.

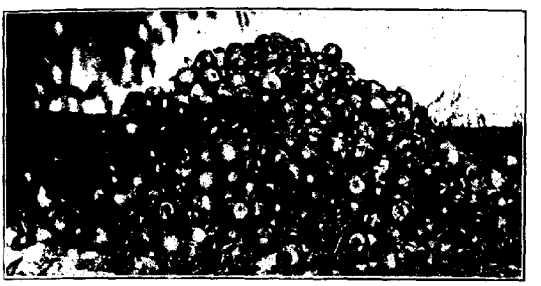


FIG. 2.—2,325 DROPPED APPLES FROM AN UNSPRAYED TREE, NEOGA, 1913



FIG. 3.—203 DROPPED APPLES FROM A PROPERLY SPRAYED TREE, NEOGA, 1913

About September 1, a very heavy drop of apples occurred from the unsprayed trees. This continued for ten days, when it suddenly stopped; very few apples fell from then until picking time. In Fig. 2 are shown 2,325 apples picked up under one unsprayed tree, while in Fig. 3 are shown 203 apples from an adjoining, properly sprayed tree. An examination of these apples revealed the presence of much codling-moth injury.

SUMMARY OF RESULTS AT NEOGA, 1913

1. Differences in the control of codling moth shown in these experiments by the various brands of arsenates of lead are attributed not so much to differences in the chemicals themselves as to unequal conditions of infection, arising chiefly from wide variations in the quantity of fruit borne by the different plats.

2. The powdered arsenates of lead proved very convenient to handle. The Vreeland brand caused a slight injury to the foliage which was not noticed in the plats sprayed with Corona dry.

3. A fourth application of arsenate of lead applied to Jonathan trees to check the ravages of second-brood codling moth was very effective, reducing the injury from this insect several percent wherever used.

4. A fourth application of arsenate of lead applied early in July failed to control third-brood codling moth, which appeared early in October, infesting unpicked apples.

5. The infestation of codling moth was the most serious in the history of the experimental work at Neoga.

6. Arsenate of lead applied at 125 pounds pressure controlled codling moth almost as well as that applied at 225 pounds pressure.

7. Bordeaux applied at 125 pounds pressure caused no injury, while pressures of 160 pounds and higher appeared to cause considerable russeting of the fruit and some foliage injury.

8. A heavy drop of Jonathan apples early in September appeared to have been caused by attacks of codling-moth.

SPRAYING EXPERIMENTS IN 1914 AT NEOGA, CUMBERLAND COUNTY

BY O. S. WATKINS

OBJECTS

The investigations at Neoga in 1914 were made to determine (1) the insecticidal efficiency of certain brands of arsenate of lead, alone and in combination with lime sulfur; (2) the fungicidal efficiency of soluble sulfur, atomic sulfur, calcium hyposulfite, copper ferrocyanide, and tuber tonic; (3) the effect of varying the pressure in applying Bordeaux; and (4) the effectiveness of certain standard nozzles. Conditions arising during the season made it possible to obtain information also on the effects of (1) special sprays applied to control delayed broods of codling moth; and (2) banding the trees as a supplementary means of controlling codling moth.

LOCATION AND DESCRIPTION OF ORCHARDS

Two apple orchards were used in carrying on these experiments. The neglected Storer orchard, located one and one-half miles northwest of Neoga, was selected for testing the fungicidal value of certain sprays applied during the dormant season. This orchard, consisting of eleven acres, was about eighteen years old, and was planted to several varieties, including Ben Davis, Winesap, and Willow. For the customary detailed experimental work, fourteen acres of trees were selected from the 120-acre orchard owned by H. A. Aldrich and Company. The experimental blocks consisted of five acres of Black Ben Davis, two acres of Grimes, and five acres of Jonathan trees. These blocks of trees were separated by rows of other varieties which were cared for by H. A. Aldrich and Company. Each block was divided into plats of from five to fourteen trees each. At regular intervals, unsprayed trees were reserved for comparison with the sprayed trees.

APPARATUS AND MATERIALS

The sprays were applied with a Friend power sprayer equipped with a New Western motor pump and 100-gallon tank. The powerful engine and large-capacity pump insured a sufficient range of pressure for all experiments, while the small tank proved convenient and efficient for applying the comparatively small amounts of spray required for each plat.

In the test of the effectiveness of various types of nozzles Bordeaux, Morrel and Morley Eclipse, Friend, and Gould Mistry nozzles were compared. In all other tests a single Friend angle nozzle was used on the tower pole and a double Gould Mistry nozzle on the ground pole. The standard spraying materials were prepared according to the directions given on pages 430 and 431, with the exceptions noted in connection with the individual experiments. A constant pressure of 135 pounds was used in all experiments except those on comparisons of pressures.

WEATHER CONDITIONS

The weather conditions of 1914 were hardly normal. There were several rains during the summer, but other conditions were such as to counteract much of the good they might have done. In May, three rains gave a precipitation of seven-eighths inch; in June, six rains gave three inches; in July, six rains gave one and one-fourth inches; in August, eight rains gave five inches; and in September, four rains gave three inches. During June there were six days when the thermometer passed 100° F., and during July there were eleven such days. The general character of the season was hot and dry, in spite of the fact that there was a reasonable total precipitation.

Full bloom was recorded from April 28 to May 1. There was very heavy bloom on the Ben Davis and the Black Ben Davis trees, a fair bloom on the Grimes, and a scattering bloom on the Jonathan trees. Excellent weather for pollination prevailed, and the blooms set well.

SPRAY DATES

All plats in the Aldrich orchard were given an application of winter-strength lime sulfur early in April. Four to six later applications were made upon or near the following dates: April 25, May 5, May 18, June 14, July 8, and September 1. The applications on June 14 and September 1, made especially to combat the ravages of codling moth, were in addition to the usual schedule.

INSECTICIDAL EFFICIENCY OF CERTAIN BRANDS OF ARSENATE OF LEAD USED ALONE AND IN COMBINATION WITH LIME SULFUR

Each plat in this group consisted of five trees of the Black Ben Davis variety. All plats were sprayed under conditions as nearly alike as possible. The brands of arsenate of lead tested and the treatments given are presented in Tables 6 and 7. Owing to the late arrival of the material, Plat 13, sprayed with Grasselli powdered arsenate of lead, and Plat 19, sprayed with the same material and lime sulfur, did not receive the first, or cluster-bud application.

EFFECT ON FOLIAGE

Careful observations disclosed no spray injury on any of the plats. Of the arsenates of lead used alone, Corona dry and Sherwin-Williams dry appeared to be the most adhesive.

EFFECT ON FRUIT

The fruit from the plats sprayed with arsenate of lead alone was picked and examined October 16 and 17, with the results presented in Table 6. The character of the codling-moth infestation was so severe as to give an excellent opportunity for testing the effectiveness of poison sprays in its control. The infestation of the two check plats was 84 and 97.3 percent, respectively. Many of the unsprayed apples were entered by several larvæ; had the individual larvæ entrances

TABLE 6.—EFFECTS OF VARIOUS BRANDS OF ARSENATE OF LEAD USED ALONE IN CONTROLLING CODLING MOTH ON BLACK BEN DAVIS APPLES, IN THE EXPERIMENTS AT NEOGA, 1914

Plat	Treatment	Applications	Picked apples				
			Total No.	Percentage No. 1	Percentage affected by codling moth		
					Calyx	Side	Total
7	2-100 Corona dry arsenate of lead	1, 2, 3, 4, 5, 6	710	80	0.4	4.3	4.7
Check	No treatment	None	332	0	12.3	85.0	97.3
8	4-100 Corona dry arsenate of lead	1, 2, 3, 4, 5, 6	2072	76	0.1	2.0	2.1
9	2-100 Sherwin-Williams dry arsenate of lead	1, 2, 3, 4, 5, 6	1916	89	0.5	5.9	6.4
10	4-100 Sherwin-Williams dry arsenate of lead	1, 2, 3, 4, 5, 6	2641	80	0.3	5.2	5.5
11	4-100 Sherwin-Williams paste arsenate of lead	1, 2, 3, 4, 5, 6	2387	84	0.2	4.4	4.6
12	4-100 Grasselli paste arsenate of lead	1, 2, 3, 4, 5, 6	1162	73	4.0	12.0	16.0
Check	No treatment	None	231	0	17.0	67.0	84.0
13	2-100 Grasselli powdered arsenate of lead	2, 3, 4, 5, 6	2688	46	4.7	27.0	31.7
14	4-100 Thomsen triplumbic paste arsenate of lead	1, 2, 3, 4, 5, 6	1704	81	0.5	6.3	6.8
15	4-100 Dow paste arsenate of lead	1, 2, 3, 4, 5, 6	1707	83	.0	3.6	3.6

been counted instead of the number of apples attacked, the infestation would have been represented by several hundred percent. In view of the severe infestation, all the treatments, except those of Plats 12 and 13, gave a satisfactory control of codling moth, the infestation ranging from 2.1 to 6.8 percent. On Plats 12 and 13, sprayed with Grasselli paste and powdered arsenates of lead, respectively, the codling-moth infestation amounted to 16 and 31.7 percent. Grasselli

powdered arsenate of lead proved difficult to keep in suspension. Corona and Sherwin-Williams dry arsenates of lead were of practically the same efficiency as the pastes. The use of 2 pounds of dry arsenate of lead in each 100 gallons of spray was almost as efficient as 4 pounds, indicating that, for practical purposes, the smaller amount is sufficiently effective.

The fruit from the plats sprayed with arsenate of lead and lime sulfur was picked and examined October 23; the results are presented in Table 7. As will be seen, there were no wide differences in the effectiveness of the different arsenates of lead in controlling codling moth. Altho not shown in the table, it should be stated that none of the sprays caused injuries of any kind to the fruit.

TABLE 7.—EFFECTS OF VARIOUS BRANDS OF ARSENATE OF LEAD USED IN COMBINATION WITH LIME SULFUR IN CONTROLLING CODLING MOTH ON BLACK BEN DAVIS APPLES, IN THE EXPERIMENTS AT NEOGA, 1914

Plat	Treatment	Applications	Picked apples			
			Total No.	Percentage affected by codling moth		
				Calyx	Side	Total
16	4-100 Dow paste arsenate of lead with lime sulfur	1, 2, 3, 5				
	2-100 Corona dry arsenate of lead with lime	4, 6	1292	2.5	8.6	11.1
17	4-100 Sherwin-Williams paste arsenate of lead with lime sulfur	1, 2, 3, 5				
	2-100 Corona dry arsenate of lead with lime	4, 6	1841	2.4	9.2	11.6
Check	No treatment	None	456	6.0	51.0	57.0
18	2-100 Sherwin-Williams dry arsenate of lead with lime sulfur	1, 2, 3, 5				
	2-100 Corona dry arsenate of lead with lime	4, 6	1412	2.5	5.0	7.5
19	2-100 Grasselli powdered arsenate of lead with lime sulfur	2, 3, 5				
	2-100 Corona dry arsenate of lead with lime	4, 6	1440	2.0	7.0	9.0
20	4-100 Thomsen triplumbic paste arsenate of lead with lime sulfur	1, 2, 3, 5				
	2-100 Corona dry arsenate of lead with lime	4, 6	876	1.0	7.0	8.0
21	2-100 Corona dry arsenate of lead with lime sulfur	1, 2, 3, 5				
	2-100 Corona dry arsenate of lead with lime	4, 6	902	1.2	8.0	9.2

A comparison of Table 6 with Table 7 shows that a better control of codling moth was exercised by arsenate of lead alone than by arse-

nate of lead with lime sulfur. The difference, tho small, was consistent enough to indicate that the lime sulfur lessened the poisoning efficiency of the arsenate of lead or else proved attractive in some way to codling moth. The latter possibility would confirm observations recorded in Bulletin 185 (page 203).

FUNGICIDAL EFFICIENCY OF SOLUBLE SULFUR, ATOMIC SULFUR, CALCIUM HYPOSULFITE, COPPER FERROCYANIDE, AND TUBER TONIC

Niagara and Grasselli soluble sulfur, Thomsen atomic sulfur, calcium hyposulfite, copper ferrocyanide, and Sherwin-Williams tuber tonic were compared on plats consisting of ten Jonathan and four Grimes trees each. Lack of fungous infection, however, prevented obtaining information relating to the fungicidal value of these sprays. Copper ferrocyanide appeared to be the most adhesive; the other sprays were about equal in this respect. The fruit sprayed with calcium hyposulfite was more highly colored than that in any of the other plats. Tuber tonic seriously burned every leaf and injured every blossom to which it was applied, entirely destroying the crop from that plat, showing conclusively that it is a worthless and dangerous spray for apples. Soluble sulfur, used alone, caused slight foliage injury. Atomic sulfur injured about 10 percent of the fruit, causing a burn similar to lime-sulfur injury.

EFFECT OF PRESSURE ON BORDEAUX RUSSET

The effects of applications of different pressures on Bordeaux russet were compared on plats each consisting of ten Jonathan and four Grimes trees. The results are not tabulated, but may be stated as follows: Bordeaux applied at pressures above 150 pounds did not cause very much russet. Apples sprayed at higher pressures, however, were not so well colored as those sprayed at 135 pounds. Grimes apples sprayed at pressures of 175 pounds and higher were covered with minute russeted specks, hardly noticeable enough, however, to lessen their selling value.

EFFECTIVENESS OF CERTAIN STANDARD NOZZLES

Each plat in this group consisted of five Black Ben Davis trees. The sprays were applied with the nozzles named in Table 8.

EFFECT ON FOLIAGE

No differences in the appearance of the foliage in the various plats could be detected. More material was required when spraying with Bordeaux nozzles than with other nozzles, as much of it was lost on the ground.

EFFECT ON FRUIT

The fruit was picked and examined October 26, giving the results presented in Table 8. There were no appreciable differences in the effectiveness of the different nozzles in their degree of control of codling moth. The drenching spray of the Bordeaux nozzle saved no more fruit from second-brood codling moth than the misty, fog-like sprays from the other nozzles. In controlling the first brood, however, this nozzle was the most efficient. Owing to the absence of fungous diseases, there was no opportunity to compare the efficiency of the different nozzles in controlling them.

TABLE 8.—EFFECTS OF USING DIFFERENT KINDS OF NOZZLES IN APPLYING STANDARD SPRAY MIXTURES TO BLACK BEN DAVIS APPLES, IN THE EXPERIMENTS AT NEOGA, 1914

Plat	Nozzle used	Picked apples			
		Total No.	Percentage affected by codling moth		
			Calyx	Side	Total
28	Bordeaux	2100	.2	16.2	16.4
29	Morrill and Morley Eclipse	732	3.2	12.6	15.8
30	One Friend and one Gould Mistry	1335	5.0	13.8	18.8
Check	No treatment	282	14.7	76.0	90.7

EFFECTS OF SPECIAL SPRAYS APPLIED TO CONTROL DELAYED BROODS OF CODLING MOTH

In 1914 most of the first-brood codling moth appeared about the middle of June, a month later than usual. Late in August and on into September an apparently delayed second brood, the offspring of the delayed first brood, appeared. As no provision had been made in the regular spray schedule for applications to control codling moth appearing at these times, it was necessary to resort to extra sprays applied as soon as a diagnosis of this unusual condition could be made. These extra sprays were applied June 14 and September 1. To learn their effectiveness, the first one was omitted from one plat, the last one from another, and both from a third. Each plat consisted of five Black Ben Davis trees. The effects of the extra sprays are shown in Table 9.

These results show that the two extra sprays saved slightly more than half the total crop, reducing the injury from 56 percent in Plat J, which received only the regular applications, to 4.7 percent in Plat G, which received both extra applications in addition to the regular sprays. One extra application was helpful, but insufficient to give a satisfactory control of codling moth.

The excellent results obtained in this experiment, carried on in a season when codling moth was at its worst, show conclusively that it

is possible to keep such close track of the development of the insect as to spray at such times as to hold it effectively in check.

TABLE 9.—EFFECTS OF SPECIAL APPLICATIONS OF ARSENATE OF LEAD APPLIED TO CONTROL DELAYED BROODS OF CODLING MOTH, IN THE EXPERIMENTS AT NEOGA, 1914

Plat	Treatment	Applications	Picked apples				
			Total No.	Percentage No. 1	Percentage affected by codling moth		
					Calyx	Side	Total
G	Four regular sprays. Extra applications in June and September	1, 2, 3, 5 4, 6	710	80	0.4	4.3	4.7
H	Four regular sprays. Extra application in September only	1, 2, 3, 5 6	496	51	8.3	29.0	37.3
I	Four regular sprays. Extra application in June only	1, 2, 3, 5 4	1360	48	11.0	23.0	34.0
J	Four regular sprays. No extra applications	1, 2, 3, 5	366	22	4.9	51.1	56.0
Check	No treatment	None	456	0	6.0	51.0	57.0

NOTE.—For all applications 2-100 Corona dry arsenate of lead with lime was used.

EFFECTS OF BANDING THE TREES AS A SUPPLEMENTARY MEANS OF CONTROLLING CODLING MOTH

When it became evident in June that a strenuous fight would have to be made to control codling moth, it was decided to place trap bands of paper or burlap on the trees in order to catch as many larvæ and pupæ as possible. The rough bark was first scraped from the tree trunks, when it is estimated that more than 6,000 larvæ were killed. Two bands were then placed on each tree, one six inches above the ground and the other just below the crotch. These were examined every seven days thruout the summer. The banding resulted in the trapping and subsequent destruction of more than 14,000 larvæ. In the bands on one of the unsprayed trees, 154 larvæ were found at one examination. It is believed, therefore, that banding is a useful supplement to spraying in controlling codling moth.

SUMMARY OF RESULTS AT NEOGA, 1914

1. Arsenate of lead, properly applied, controlled codling moth in spite of the severe 1914 infestation.

2. Arsenate of lead received from the Grasselli Chemical Company was less efficient in the control of codling moth than Corona dry,

Sherwin-Williams paste and dry, Thomsen triplumbic paste, and Dow paste arsenates of lead.

3. Corona dry and Sherwin-Williams dry arsenates of lead were equivalent in efficiency to the pastes.

4. Two pounds of Corona dry and two pounds of Sherwin-Williams dry arsenate of lead were practically as efficient as four pounds of the same material, as well as four pounds of any of the standard paste arsenates of lead.

5. All the arsenates of lead were less effective when used with lime sulfur than when used alone.

6. Copper ferrocyanide proved to be very adhesive.

7. Fruit sprayed with calcium hyposulfite was very highly colored.

8. Sherwin-Williams tuber tonic caused severe injury to the foliage and fruit.

9. Niagara soluble sulfur and Grasselli soluble sulfur caused a small amount of foliage injury.

10. Thomsen atomic sulfur burned about 10 percent of the fruit.

11. Drenching trees by the use of the Bordeaux nozzle did not prove any more efficient than spraying thru nozzles producing a mist in controlling second-brood codling moth, but was more efficient in controlling the first brood.

12. Owing to the irregularity with which codling moth appeared, over half the fruit from trees which were not given special applications for the delayed broods was infested.

13. Thirty-seven percent of the fruit from trees given one special application in September was injured by codling moth; 34-percent infestation resulted when one special application was given in June; while in properly sprayed fruit, receiving four regular applications and two special applications, the injury amounted to only 5 percent.

14. Banding trees with paper or burlap bands was found a satisfactory means of trapping the larvæ of the codling moth, thus affording an opportunity to kill them before they had transformed into moths.

SPRAYING EXPERIMENTS IN 1913 AT FLORA, CLAY COUNTY

BY W. A. RUTH, ASSOCIATE IN HORTICULTURAL CHEMISTRY

OBJECTS

The principal object of this experiment was to determine the effect of varying the amount of Bordeaux applied, the pressure at which the spray was applied, and the size of the nozzle openings, on the production of Bordeaux russet. A secondary object was to determine the effect of varying these factors on the control of insects and fungi.

BORDEAUX RUSSET: DESCRIPTION AND CAUSE

Aside from producing foliage injury, Bordeaux will bring about severe russeting of the fruit if applied to certain varieties of apples under certain conditions. Some varieties are more subject to russeting than others; the varieties Ben Davis and Jonathan, upon which this experiment was carried out, may be classed among the more susceptible. The russeting is due to the production of corky material which replaces the surface injured by the spray. This corky surface is usually light brown, but may be dark brown or black if the russeted areas are very small. The injury may be confined to scattered dots; if more severe, there may be irregular russeted streaks as well as dots; and if very severe, all or a large part of the surface of the fruit may be russeted.

The injury, according to Hedrick,[1] follows applications of Bordeaux made early in the season; later in the season, according to this investigator, after the hairs have been shed and the stomata changed into lenticels, immunity is probably acquired. At Flora, in experiments conducted by the writer in 1912 with Ben Davis and Jonathan trees, the application of Bordeaux made in April, just before the bloom, and the two following the bloom, made in May, all caused serious damage.[2] The application of this material made about July 1, however, when the apples were acquiring a waxy surface, caused no severe russet; a slight dotting was produced at this time, but it became inconspicuous by the time the fruit was ready to be picked. Experiments conducted with Ben Davis trees by Mr. A. J. Gunderson[2] at Griggsville showed that any one of the early applications of Bordeaux may result in the culling of a large part of the crop.

When Bordeaux was first used there was little complaint of injury. The apparatus with which the material was applied at that time was

[1] U. P. Hedrick, New York (Geneva) Agr. Exp. Sta. Bul. 287, p. 163.
[2] J. C. Blair et al., Ill. Agr. Exp. Sta. Bul. 185.

very crude compared with the machinery now employed. On account of the much greater pressures used since power sprayers have reached their present state of perfection, the increase in russeting has often been attributed to these greater pressures. A further basis for the assumption that pressure is a most important factor in the formation of russet is the difference in the severity of the russeting often to be observed in commercial orchards sprayed at high and at low pressures. In support of this idea a mechanical explanation was apparently at hand. According to this explanation the damage follows punctures made by gritty particles in the Bordeaux, and the number of the punctures and the severity of the resultant injury increase with the pressure.

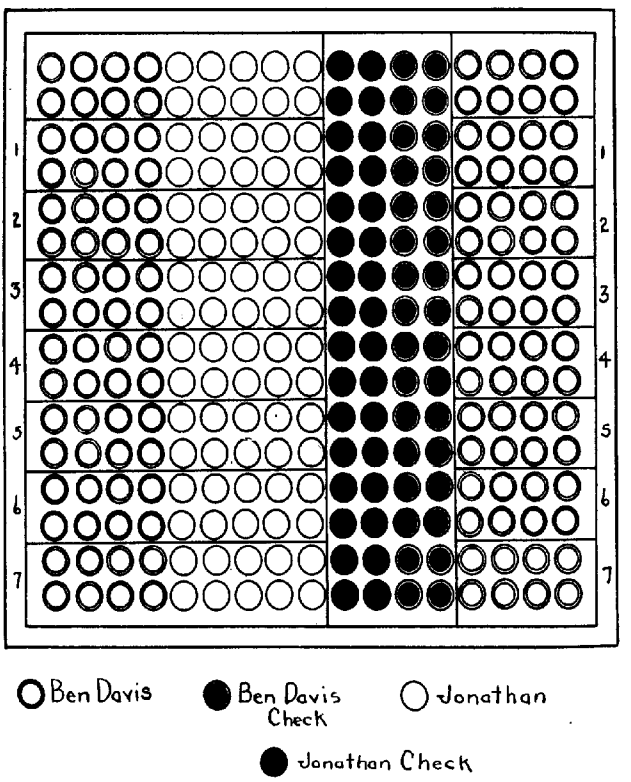


FIG. 4.—PLAN OF PLATS IN ORCHARD OF MRS. JOHN EGGINTON, FLORA, 1913
NOTE.—The neglected orchard was located immediately to the right.

It can hardly be assumed that a difference in the pressure is the only difference between the methods now used for applying the spray and those used formerly, or between high and low pressure spraying. More thoro spraying is probably done with power sprayers than was done before they came into use, and larger amounts of spray material per tree are no doubt being applied. Moreover, larger amounts are usually applied at high pressures than at low pressures. The pressure indicated at the pump cannot be assumed to be an accurate indicator of the striking force of the particles; the type of nozzle and the size of the nozzle openings affect the size of the drops of spray, and, in all probability, their striking force to at least as great an extent as their size. Even with nozzle openings of a uniform size, a high pressure breaks the spray into finer particles than does a low pressure.[1] It may therefore be imagined that the possible striking and injuring force may be actually greater if low pressures are used than would result from the use of high pressures, especially if large nozzle openings are used with the low pressures, and small nozzle openings with the high.

LOCATION AND DESCRIPTION OF ORCHARD

The orchard used in this experiment was the property of Mrs. John Egginton, and was located four and one-half miles west of Flora. The trees, which were well cared for, were seventeen years old the season of the experiment. A gradual, even slope, and a draw adjoining the lower end, provided good air drainage, especially for the upper third of the orchard, across which the plats were run. A neglected orchard immediately adjoined this part of the orchard. The arrangement of the plats is shown in Fig. 4.

TREATMENT

In order to restrict the number of plats, but one high and one low pressure were tested, one size of large nozzle opening and one size of small, and, as far as possible, a uniform large and a uniform small amount of spray. To obtain all the possible combinations of the three factors the experiment would have included eight treatments. The possible combinations and the methods used are shown in Table 10. Bordeaux arsenate of lead was used for the first and fourth applications, and lime sulfur arsenate of lead for the two intermediate applications.

When small amounts of spray were applied, the foliage was covered lightly but thoroly. With large amounts, the foliage was drenched. There was more or less unavoidable variation in the amounts applied to the plats in each class. The spray was applied from the upper side, most of the spray which reached the under sides of the leaves being that carried thru the tree at the high pressure. The high pressure

[1] J. W. Lloyd, Ill. Agr. Exp. Sta. Bul. 114, p. 385.

was between 225 and 250 pounds, the low pressure, between 125 and 150 pounds. The large nozzle openings had twice the area of the small nozzle openings.

TABLE 10.—TREATMENTS IN THE EXPERIMENTS AT FLORA, 1913

Plat	Pressure	Amount of spray	Size of nozzle openings
1	High	Large	Large
2	Low	Large	Large
3	Low	Small	Large
[1]	High	Small	Large
4	High	Small	Small
5	Low	Small	Small
6	High	Large	Small
7	Low	Large	Small

[1]Because of the difficulty involved in distributing a small amount of spray evenly at a high pressure with large nozzle openings, this combination of factors was not tested.

The material was applied in the following manner: Each plat was completely sprayed at one time, with material made up and carried in one load. Each plat was sprayed from one side, thru the middle, and then from the other side, so that the trees of both varieties were finished practically at the same time, and that any possible differences in the method of spraying, which in any case would be slight, would be equalized as far as possible between the varieties.

The first, second, and third applications, which are, taken together, responsible for the control of scab, leaf spot (*Sphæropsis malorum* Pk.), first-brood codling moth, and the apple-leaf roller (*Archips rosaceana* Harris), were applied at favorable times. The third application is also partly responsible for the control of blotch. The apple flea-weevil (*Orchestes canus* Horn) confines its feeding to the earlier part of the season, and would be controlled by the early sprays if it is to be controlled according to the present schedule. The fourth application, which is designed to be partly responsible for the control of blotch (*Phyllosticta solitaria* E. & E.), directly responsible for the control of second-brood codling moth, and indirectly responsible for the control of the third brood, was applied too late to be of any great benefit.

APPARATUS AND MATERIALS

The sprays were prepared according to the methods described on pages 430 and 431. The Illinois formula was used in making the lime sulfur. Grasselli paste arsenate of lead, at the rate of 4 pounds to 100 gallons of spray, was always added to the fungicide.

In applying the sprays, Bean whirlpool nozzles were used. The discs of these nozzles, which are interchangeable, are regularly fur-

ished with holes approximately .07 or .05 inch in diameter, and these ...s were used as the "large" and the "small" nozzle openings. The ...hirlpool type of nozzle is made by several firms, and is in common ...e in commercial orchards. Two power sprayers were used, one for ...he high-pressure sprays, the other for those applied at the low pres...sure. Both outfits were equipped with good propeller agitators.

WEATHER CONDITIONS

The weather during April, May, and the first part of June was very cool, and there was enough moisture to allow an attack of scab and blotch. The remainder of the season was unusually hot and dry. Conditions were favorable for the multiplication of codling moth.

SPRAY DATES

Four summer applications were made upon the following dates: April 17 to 19, May 7 to 8, May 28 to 31, and August 8 to 10. The fourth application was made after the danger of Bordeaux russeting was past.

EFFECT OF THE SPRAYS ON FOLIAGE

Leaf spot was thoroly controlled on all the sprayed trees, but caused a heavy loss of foliage on the unsprayed Ben Davis trees. A severe scab infection was present on the Ben Davis fruit, altho the foliage of the check trees of both varieties was almost free from this injury.

By the middle of June the foliage of both the sprayed and the unsprayed trees was thoroly riddled by apple flea-weevil. The first overwintering adults were observed April 3; the adults of the new generation were present on the foliage in the greatest numbers during the latter part of May and the first two weeks in June.

At the ends of the plats immediately adjoining the neglected orchard, apple-leaf rollers severely damaged the foliage of two or three rows of trees. On the trees farther away, the sprays controlled these insects to a large extent.

EFFECT OF THE SPRAYS ON FRUIT

The effects of varying each one of the three factors, pressure, amount, and size of nozzle opening, as tested on each of the two varieties, are presented in Tables 11 to 16. In each table three plats are compared with three other plats; each of the three plats shown on one side of the table was treated similarly to the opposite one of the other three, except for one varying factor common to the entire group of six. In the first two tables the pressure at which the spray was

applied is the common varying factor; in the next two it is the amount of spray; and in the last two it is the size of the nozzle openings.

On account of the large number of codling moths and the small and scattered crop of fruit, the degree of control of these insects cannot be attributed entirely to the relative efficiency of the various treatments. It is well known that, with a small crop and an abundance of moths, control is especially difficult. When the set of fruit varies among various plats, following a scattered bloom, as it did in this experiment, especially on the Ben Davis trees, differences in control must be due to some extent to differences in the set. For this reason, codling-moth data of Ben Davis fruit are omitted in the following tables. The data for the control of these insects entering the calyxes of the Jonathans, however, seem to be fairly consistent, and are therefore presented. All the picked Jonathans were examined for the various injuries recorded, but only the Ben Davis apples from the end of the plats farthest from the neglected orchard.

TABLE 11.—EFFECT OF SPRAYING BEN DAVIS APPLES WITH DIFFERENT PRESSURES, IN THE EXPERIMENTS AT FLORA, 1913[1]

Amount of spray	Size of nozzle openings	High pressure				Low pressure			
		Plat	Percentage of picked apples affected by—			Plat	Percentage of picked apples affected by—		
			Scab	Blotch	Severe russet		Scab	Blotch	Severe russet
Large	Large	1	.0	6.2	30.6	2	.0	3.7	33.4
Small	Small	4	5.5	29.4	13.9	5	8.8	32.3	8.3
Large	Small	6	.5	13.3	23.8	7	4.6	13.6	25.3
		Average	2.0	16.3	22.8	Average	4.5	16.5	22.3
No treatment.....		Check	62.2	56.6	2.1	Check	62.2	56.6	2.1

TABLE 12.—EFFECT OF SPRAYING JONATHAN APPLES WITH DIFFERENT PRESSURES, IN THE EXPERIMENTS AT FLORA, 1913[1]

Amt. of spray	Size of nozzle openings	High pressure					Low pressure				
		Plat	Percentage of picked apples affected by—				Plat	Percentage of picked apples affected by—			
			Scab	Blotch	Codling moth (calyx)	Severe russet		Scab	Blotch	Codling moth (calyx)	Severe russet
Large	Large	1	.9	6.1	6.3	5.7	2	.2	5.4	4.8	17.9
Small	Small	4	2.0	19.5	13.8	7.7	5	2.5	18.9	23.2	18.4
Large	Small	6	.6	5.5	4.0	36.9	7	1.0	11.2	11.4	37.5
		Average	1.2	10.4	8.0	16.8	Average	1.2	11.8	13.1	24.6
No treatment		Check	34.9	52.6	50.1	2.9	Check	34.9	52.6	50.1	2.9

[1]Each plat was sprayed four times; Bordeaux arsenate of lead was used for the first and fourth applications, and lime sulfur arsenate of lead for the two intermediate applications.

EFFECT OF VARYING THE PRESSURE

On the Ben Davis apples, the amount of russet produced by the spray was practically equal at both pressures. On the Jonathan apples, more russet was produced, in every case, at low than at high pressure. On both varieties, blotch and scab were controlled, on the average, with almost equal thoroness at both pressures. The control of codling moths entering the calyxes of the Jonathans was better, on the average, where the spray was applied at high pressure.

EFFECT OF VARYING THE AMOUNT OF SPRAY

In every case where comparisons could be made, the use of a large amount of spray resulted in decidedly more russet than the use of a small amount. The control of scab and blotch on both varieties, and of codling moths entering the calyxes of the Jonathans, was better, and with one exception much better, where large amounts of spray were used.

TABLE 13.—EFFECT OF SPRAYING BEN DAVIS APPLES WITH DIFFERENT AMOUNTS, IN THE EXPERIMENTS AT FLORA, 1913[1]

Pressure	Size of nozzle openings	Large amount				Small amount			
		Plat	Percentage of picked apples affected by—			Plat	Percentage of picked apples affected by—		
			Scab	Blotch	Severe russet		Scab	Blotch	Severe russet
Low	Large	2	.0	3.7	33.4	3	4.4	32.8	15.8
High	Small	6	.5	13.3	23.8	4	5.5	29.4	13.9
Low	Small	7	4.6	13.6	25.3	5	8.8	32.3	8.3
		Average	1.7	10.2	27.5	Average	6.2	31.5	12.7
No treatment		Check	62.2	56.6	2.1	Check	62.2	56.6	2.1

TABLE 14.—EFFECT OF SPRAYING JONATHAN APPLES WITH DIFFERENT AMOUNTS, IN THE EXPERIMENTS AT FLORA, 1913[1]

Pressure	Size of nozzle openings	Large amount					Small amount				
		Plat	Percentage of picked apples affected by—				Plat	Percentage of picked apples affected by—			
			Scab	Blotch	Codling moth (calyx)	Severe russet		Scab	Blotch	Codling moth (calyx)	Severe russet
Low	Large	2	.2	5.4	4.8	17.9	3	1.5	14.4	7.9	9.0
High	Small	6	.6	5.5	4.0	36.9	4	2.0	19.5	13.8	7.7
Low	Small	7	1.0	11.2	11.4	37.5	5	2.5	18.9	23.2	18.4
		Average	.6	7.4	6.7	30.8	Average	2.0	17.6	15.0	11.7
No treatment		Check	34.9	52.6	50.1	2.9	Check	34.9	52.6	50.1	2.9

[1] Each plat was sprayed four times; Bordeaux arsenate of lead was used for the first and fourth applications, and lime sulfur arsenate of lead for the two intermediate applications.

EFFECT OF VARYING THE SIZE OF THE NOZZLE OPENINGS

In every case more russet was produced on the Ben Davis apples sprayed with large nozzle openings than on those sprayed with small nozzle openings, while the opposite result was produced in every case on the Jonathans. On the average, three times as much russet appeared on Jonathan apples sprayed with large nozzle openings as on those sprayed with small nozzle openings. The difference may be due to a greater susceptibility of the Jonathan tissue to a small amount of Bordeaux, in comparison to its susceptibility to a large amount, and to a better distribution of the spray. The better distribution, which would follow the use of small nozzle openings and the production of a finer mist, might result in the production of a greater number of smaller covered areas. The use of low pressures, in comparison with high pressures, modifies the distribution in the same way, and, as has been stated in the discussion of the effect of varying the pressure, produces the same result.

TABLE 15.—EFFECT OF SPRAYING BEN DAVIS APPLES WITH DIFFERENT-SIZED NOZZLE OPENINGS, IN THE EXPERIMENTS AT FLORA, 1913[1]

Pressure	Amount of spray	Large nozzle openings				Small nozzle openings			
		Plat	Percentage of picked apples affected by—			Plat	Percentage of picked apples affected by—		
			Scab	Blotch	Severe russet		Scab	Blotch	Severe russet
High	Large	1	.0	6.2	30.6	6	.5	13.3	23.8
Low	Large	2	.0	3.7	33.4	7	4.6	13.6	25.3
Low	Small	3	4.4	32.8	15.8	5	8.8	32.3	8.3
		Average	1.5	14.2	26.6	Average	4.6	19.7	19.1
No treatment.....		Check	62.2	56.6	2.1	Check	62.2	56.6	2.1

TABLE 16.—EFFECT OF SPRAYING JONATHAN APPLES WITH DIFFERENT-SIZED NOZZLE OPENINGS, IN THE EXPERIMENTS AT FLORA, 1913[1]

Pressure	Amt. of spray	Large nozzle openings					Small nozzle openings				
		Plat	Percentage of picked apples affected by—				Plat	Percentage of picked apples affected by—			
			Scab	Blotch	Codling moth (calyx)	Severe russet		Scab	Blotch	Codling moth (calyx)	Severe russet
High	Large	1	.9	6.1	6.3	5.7	6	.6	5.5	4.0	36.9
Low	Large	2	.2	5.4	4.8	17.9	7	1.0	11.2	11.4	37.5
Low	Small	3	1.5	14.4	7.9	9.0	5	2.5	18.9	23.2	18.4
		Average	.9	8.6	6.3	10.9	Average	1.4	11.9	12.9	30.9
No treatment.		Check	34.9	52.6	50.1	2.9	Check	34.9	52.6	50.1	2.9

[1]Each plat was sprayed four times; Bordeaux arsenate of lead was used for the first and fourth applications, and lime sulfur arsenate of lead for the two intermediate applications.

The control of scab and blotch was better on Ben Davis apples when large nozzle openings were used. The same was true for blotch and codling-moth calyx injury on the Jonathans. Scab on the Jonathans was controlled almost equally well when large and small nozzle openings were used.

SUMMARY OF RESULTS AT FLORA, 1913

1. The amount of spray applied was the most important factor in the production of russet; large amounts increased this injury, but were more effective in protecting the fruit from scab, blotch, and codling moth entering the calyxes, than were small amounts.

2. It was conclusively shown that applying the spray at high pressure did not increase the amount of Bordeaux russet. The pressure employed had no effect on the control of scab or blotch, but the value of high pressures in the control of codling-moth calyx injury was indicated.

3. On the Ben Davis apples, a greater amount of russet was produced where large nozzle openings were used than where small nozzle openings were used; on the Jonathan apples, the use of small nozzle openings gave the greater amount of russet. Large nozzle openings gave a better control, in general, of scab, blotch, and codling-moth calyx injury.

4. Spraying was of no value in controlling the apple flea-weevil.

5. The foliage of all the sprayed plats was well protected from leaf spot.

6. The foliage of all the sprayed plats was well protected from the apple-leaf roller except on the trees adjoining the neglected orchard.

SPRAYING EXPERIMENTS IN 1913 AT GRIGGSVILLE, PIKE COUNTY

BY ALFRED J. GUNDERSON, FIRST ASSISTANT IN POMOLOGY

OBJECTS

In the spraying work at Griggsville during 1913, experiments were conducted with a view to studying the following points in summer spraying: (1) the relative values of lime sulfur and Bordeaux; (2) the effects of using Bordeaux for some applications and lime sulfur for other applications in the same season's operations; (3) the relative values of paste and powdered arsenates of lead; (4) the relative values of various strengths of lime sulfur; (5) the fungicidal and insecticidal values of copper ferrocyanide made in different ways; (6) the relative values of proprietary lime-sulfur compounds; (7) the relative values of light and heavy applications of lime sulfur arsenate of lead and Bordeaux arsenate of lead.

LOCATION AND DESCRIPTION OF ORCHARD

The orchard used for these experiments belonged to Mr. C. G. Winn, and was located one and one-half miles south of Griggsville. A block of 179 fifteen-year-old Ben Davis trees, planted thirty-two feet apart each way, was chosen for the work.

In laying out the experiments, the trees were divided into twenty-eight plats of four to six trees each, and two unsprayed or check rows were left thru the entire length of the orchard. The plats which were to be compared were grouped, and those of each group were sprayed as nearly as possible under the same conditions. The arrangement of the plats is shown in Fig. 5.

APPARATUS AND MATERIALS

The standard sprays were prepared as described on pages 430 and 431. Applications were made with a Gould hand spray outfit at 115 to 125 pounds pressure. Friend disc nozzles were used.

WEATHER CONDITIONS

The weather during April, May, and the first part of June was cool, with very little rain. The remainder of the season was unusually hot and dry.

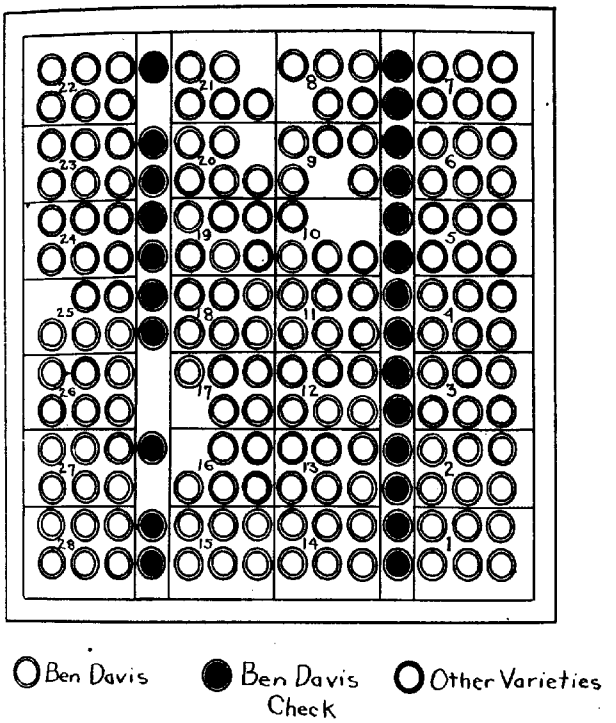


FIG. 5.—PLAN OF PLATS IN ORCHARD OF C. G. WINN, GRIGGSVILLE, 1913

SPRAY DATES

Three summer applications were made upon the following dates: April 21 to 23, May 6 to 9, and May 20 to 23.

RELATIVE VALUES OF LIME SULFUR AND BORDEAUX

Experiments at Griggsville during 1912 showed lime sulfur and Bordeaux to be equally effective in the control of scab.[1] The apples sprayed with lime sulfur had higher color and finish and the foliage was more vigorous than where Bordeaux was used. The comparison of these two sprays was continued in 1913, however, to gain further information regarding the relative values of the two sprays. Two plats were treated as shown in Table 17.

[1] J. C. Blair et al., Ill. Agr. Exp. Sta. Bul. 185, p. 176.

EFFECT ON FOLIAGE

The foliage of the unsprayed plat as well as that of both sprayed plats was free from scab during the entire season. The foliage of the plat sprayed with lime sulfur was more vigorous than that sprayed with Bordeaux. The former plat was practically free from spray injury, while on the latter plat considerable spray injury appeared late in September in the form of brown spots. Both plats showed a slight amount of leaf spot (*Sphæropsis malorum*), but a comparison with the infection present on the unsprayed trees shows that the sprays were reasonably effective in controlling this disease.

EFFECT ON FRUIT

The apples from these plats were picked and examined September 30. The results are given in Table 17. The comparative fungicidal values of lime sulfur and Bordeaux were less conclusively shown than had been hoped for, because fungous diseases were present in only small amounts. Both sprays gave perfect control of scab and sooty blotch.

Plat 1, sprayed with Bordeaux, showed even more damage from codling moth than the unsprayed plat and four times more than Plat 2, sprayed with lime sulfur. It is believed, however, that this was due to uneven infestation rather than to the effects of the treatment. Curculio injury was reduced from 67.83 percent on the unsprayed plat to 21.94 percent on Plat 1, and to 10.3 percent on Plat 2.

The most important difference between the effects of these sprays upon the fruit is shown in the amount of russet recorded. There was 64 percent serious and 26.5 percent slight russet on the fruit from trees sprayed with Bordeaux, as compared with .5 percent serious and 3.05 percent slight russet on the fruit from trees sprayed with lime sulfur. However, the amount of russet recorded for the unsprayed trees was .66 percent serious and 2.5 percent slight; hence it may be concluded that lime sulfur was not responsible for the russet on the trees sprayed with that material, and that 63.34 percent serious and 24 percent slight russet, in Plat 1, can be attributed to Bordeaux injury.

The grade percentages show that the plat sprayed with lime sulfur produced 48 percent No. 1's, 23 percent No. 2's, and 29 percent culls as compared with 9 percent, 15 percent, and 76 percent of the same grades, respectively, produced by the plat sprayed with Bordeaux. The latter plat had fewer No. 1's and more culls than the unsprayed plat. These differences were due to Bordeaux russet. The apples sprayed with lime sulfur had excellent color and finish at picking time, and were of good size. Those sprayed with Bordeaux, on the other hand, lacked color, and were very small, badly russeted, and distorted.

TABLE 17.—EFFECTS OF BORDEAUX AND LIME SULFUR IN COMBINATION WITH ARSENATE OF LEAD, IN THE EXPERIMENTS AT GRIGGSVILLE, 1913

Plat	Treatment	Applications	Percentage grades of picked apples			Percentage of picked apples affected by—								
						Scab		Sooty blotch		Codling moth		Curculio	Russet	
			No. 1	No. 2	Culls	Serious	Slight	Serious	Slight	Calyx	Side	Serious	Serious	Slight
1	Bordeaux arsenate of lead	1, 2, 3	9	15	76	.00	.00	.00	.00	2.71	31.08	21.94	64.00	26.50
2	Lime sulfur arsenate of lead	1, 2, 3	48	23	29	.00	.00	.00	.00	.00	7.25	10.30	.50	3.05
Check A	No treatment	None	21	16	63	.58	1.75	6.66	16.08	2.50	12.75	67.83	.66	2.50

TABLE 18.—EFFECTS OF USING BORDEAUX FOR SOME APPLICATIONS AND LIME SULFUR FOR OTHER APPLICATIONS IN THE SAME SEASON'S OPERATIONS, IN THE EXPERIMENTS AT GRIGGSVILLE, 1913

Plat	Treatment	Applications	Percentage grades of picked apples			Percentage of picked apples affected by—								
						Scab		Sooty blotch		Codling moth		Curculio	Russet	
			No. 1	No. 2	Culls	Serious	Slight	Serious	Slight	Calyx	Side	Serious	Serious	Slight
1	Bordeaux arsenate of lead	1, 2, 3	9	15	76	.00	.00	.00	.00	2.71	31.08	21.94	64.00	26.50
2	Lime sulfur arsenate of lead	1, 2, 3	48	23	29	.00	.00	.00	.00	.00	7.25	10.30	.50	3.05
3	Bordeaux arsenate of lead	1												
	Lime sulfur arsenate of lead	2, 3	39	23	38	.00	.00	.00	1.04	.33	14.27	13.70	7.12	24.83
4	Lime sulfur arsenate of lead	1, 2												
	Bordeaux arsenate of lead	3	22	26	52	.00	.00	.00	.00	.16	10.50	12.16	23.00	63.50
5	Bordeaux arsenate of lead	1, 3												
	Lime sulfur arsenate of lead	2	31	27	42	.00	.00	.00	.10	.70	12.70	10.30	30.00	44.90
Check A	No treatment	None	21	16	63	.58	1.75	6.66	16.08	2.50	12.75	67.83	.66	2.50

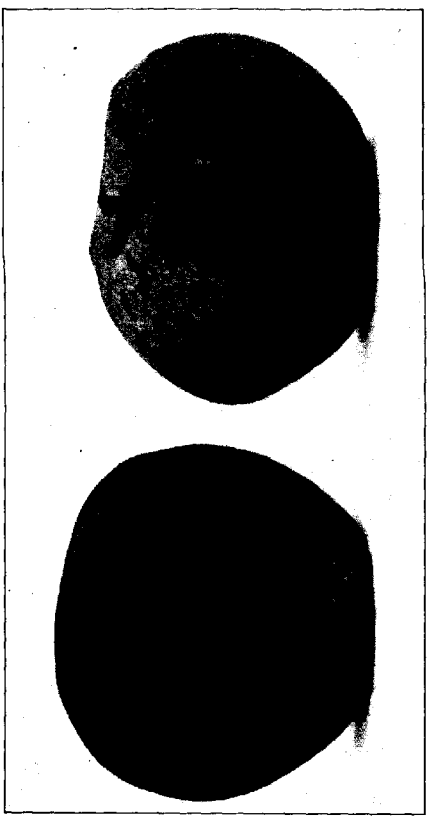


FIG. 6.—THE APPLE ON THE LEFT WAS FROM A TREE SPRAYED WITH LIME SULFUR, THAT ON THE RIGHT FROM A TREE SPRAYED WITH BORDEAUX

EFFECTS OF USING BORDEAUX FOR SOME APPLICATIONS AND LIME SULFUR FOR OTHER APPLICATIONS IN THE SAME SEASON'S OPERATIONS

The effect of using Bordeaux for some applications and lime sulfur for other applications in the same season's operations was made the subject of an experiment in which plats were treated as shown in Table 18.

EFFECT ON FOLIAGE

No scab appeared on the foliage of the sprayed plats during the entire season. A slight amount of spray injury appeared late in September, and also a light infection of frog-eye fungus (*Sphæropsis malorum*). In general, however, the foliage of these plats was vigorous and healthy.

EFFECT ON FRUIT

The apples from these plats were picked and examined September 30 and October 1. The results are given in Table 18. These results show that all the sprayed apples were free from scab and that sooty blotch was almost perfectly controlled. The brood of codling moth entering at the calyx was well controlled in Plats 2, 3, 4, and 5. The irregular and inconsistent results shown in the control of codling moth entering at the side, mostly larvæ of the late brood, indicate that three applications of spray made early in the season were ineffective in preventing damage by codling moth appearing late in the season. Curculio injury was greatly reduced by all the treatments.

Here again the most important differences are brought out in the russet columns. Since the unsprayed plat showed .66 percent serious and 2.5 percent slight russet, the true effects of the sprays are determined by subtracting the amounts of russet on the unsprayed trees from those on the sprayed trees. Thus we find that in Plat 3, Bordeaux applied at the cluster-bud stage actually caused 6.46 percent serious and 22.33 percent slight russet; that in Plat 4, Bordeaux applied two weeks after the fall of the bloom caused 22.34 percent serious and 61 percent slight russet; and that in Plat 5, Bordeaux applied both at the cluster-bud stage and two weeks after the fall of the bloom caused 29.34 percent serious and 42.4 percent slight russet. These results indicate, then, that Bordeaux, under the conditions of this experiment, when applied either just before the bloom or within two weeks after the fall of the bloom, will russet the fruit. Russet greatly reduced the color and smoothness of the apples on all plats sprayed with one or more applications of Bordeaux.

TABLE 19.—EFFECTS OF A POWDERED ARSENATE OF LEAD IN COMPARISON WITH A PASTE ARSENATE OF LEAD, IN THE EXPERIMENTS AT GRIGGSVILLE, 1913

Plat	Treatment	Applications	Percentage grades of picked apples			Percentage of picked apples affected by—								
						Scab		Sooty blotch		Codling moth		Curculio	Russet	
			No. 1	No. 2	Culls	Serious	Slight	Serious	Slight	Calyx	Side	Serious	Serious	Slight
6	Arsenate of lead (paste) alone	1, 2, 3	41	30	29	.00	.00	.00	1.25	.12	9.77	6.82	.00	1.00
7	Arsenate of lead (powdered) alone	1, 2, 3	56	23	21	.40	1.70	.30	.00	.24	9.11	9.01	.10	.90
8	Bordeaux arsenate of lead (powdered)	1, 2, 3	25	28	47	.00	.00	.00	.00	.20	10.80	14.00	49.60	38.80
9	Lime sulfur arsenate of lead (powdered)	1, 2, 3	52	23	25	.00	.00	.00	.00	.40	8.67	5.96	1.62	7.13
Check A	No treatment	None	21	16	63	.58	1.75	6.66	16.08	2.50	12.75	67.83	.66	2.50

NOTE.—Corona dry and Grasselli paste arsenates of lead were used.

TABLE 20.—EFFECTS OF VARIOUS STRENGTHS OF LIME SULFUR IN COMBINATION WITH ARSENATE OF LEAD, IN THE EXPERIMENTS AT GRIGGSVILLE, 1913

Plat	Treatment	Applications	Percentage grades of picked apples			Percentage of picked apples affected by—								
						Scab		Sooty blotch		Codling moth		Curculio	Russet	
			No. 1	No. 2	Culls	Serious	Slight	Serious	Slight	Calyx	Side	Serious	Serious	Slight
10	Lime sulfur (1 in 12) arsenate of lead	1, 2, 3	52	26	22	.00	.00	.00	.00	.00	4.87	4.73	1.16	7.61
11	Lime sulfur (1 in 14) arsenate of lead	1, 2, 3	49	23	28	.00	.00	.00	.00	.30	6.10	4.30	.70	6.80
12	Lime sulfur (1 in 18) arsenate of lead	1, 2, 3	53	24	23	.00	.00	.00	.00	.16	8.00	4.83	.33	1.16
13	Lime sulfur (1 in 24) arsenate of lead	1, 2, 3	37	45	18	.00	.00	.00	.00	.00	5.66	9.83	.50	1.50
14	Lime sulfur (1 in 36) arsenate of lead	1, 2, 3	49	18	33	.00	.00	.00	.00	.40	14.56	14.12	.20	1.46
15	Lime sulfur (1 in 72) arsenate of lead	1, 2, 3	44	17	39	.00	.00	.00	.00	.25	5.87	21.00	.12	.24
Check A	No treatment	None	21	16	63	.58	1.75	6.66	16.08	2.50	12.75	67.83	.66	2.50

RELATIVE VALUES OF PASTE AND POWDERED ARSENATES OF LEAD

The standard brands of arsenate of lead used in the spraying experiments previous to 1913 were in the paste form. Such powdered arsenates of lead as had appeared up to that time had not proved satisfactory. In 1913 a new powdered arsenate of lead, Corona dry, showed promising qualities in laboratory tests and was accordingly included in the schedule of treatments in the field tests. Plats were sprayed with powdered and paste forms, separately and in combination with Bordeaux and lime sulfur, as shown in Table 19.

EFFECT ON FOLIAGE

The foliage of Plats 6 and 7 was very good thruout the season. It was free from scab, and showed only a slight amount of tip and edge burning due to the spray. Plat 8, however, sprayed with Bordeaux arsenate of lead (powdered), showed considerable spray injury late in the season. The foliage of Plat 9, where lime sulfur arsenate of lead (powdered) was used, was excellent.

EFFECT ON FRUIT

The apples from these plats were picked and examined October 2 and 3. As will be seen in Table 19, all the sprayed plats were entirely free from scab except Plat 7, where an insignificant infection appeared. No scab or sooty blotch appeared in the plats where Bordeaux and lime sulfur were used with the arsenate of lead. Very slight infection of sooty blotch occurred in Plats 6 and 7, where the paste and powdered arsenates of lead, respectively, were used alone. From the amount of infection present in the check plat, it would appear that these sprays had exercised a beneficial fungicidal action.

The brood of codling moth entering at the calyx was effectively reduced by both the paste and the powdered arsenate of lead. Control of codling-moth side injury, however, was less effective. Both forms of arsenate of lead greatly reduced curculio injury, with no special advantage in favor of either.

The plat sprayed with powdered arsenate of lead produced a larger percentage of No. 1 apples than that sprayed with paste arsenate of lead, but the records of insect and fungous injuries indicate that other factors than the sprays were responsible for this result. Neither paste nor powdered arsenate of lead used alone appeared to cause spray russet; there was less on the apples sprayed with these materials than on the apples in the check plats. The color, finish, and size of the fruit in Plats 6 and 7 were excellent.

It is concluded from these experiments, therefore, that in every way the powdered form of arsenate of lead used (Corona) is as effective as the paste (Grasselli) with which it was compared.

TABLE 21.—EFFECTS OF DIFFERENT METHODS OF MAKING COPPER FERROCYANIDE ON ITS FUNGICIDAL VALUE, IN THE EXPERIMENTS AT GRIGGSVILLE, 1913

Plat	Treatment	Applications	Percentage grades of picked apples			Percentage of picked apples affected by—								
						Scab		Sooty blotch		Codling moth		Curculio	Russet	
			No. 1	No. 2	Culls	Serious	Slight	Serious	Slight	Calyx	Side	Serious	Serious	Slight
16	Copper ferrocyanide alone (2-2-100); mixed, concentrated, and hot	1, 2, 3	19	15	66	.00	.00	.00	.00	6.87	22.57	55.08	.36	.50
19	Copper ferrocyanide arsenate of lead (2-2-4-100); mixed, concentrated, and hot	1, 2, 3	50	17	33	.00	.00	.00	3.45	.39	10.76	8.56	.33	1.66
17	Copper ferrocyanide alone (2-2-100); mixed, concentrated, and cold	1, 2, 3	22	14	64	.00	.16	.66	2.50	11.33	20.83	57.33	.00	.00
20	Copper ferrocyanide arsenate of lead (2-2-4-100); mixed, concentrated and cold	1, 2, 3	46	23	31	.00	.16	.16	.33	.16	8.33	13.00	.00	.00
18	Copper ferrocyanide alone (2-2-100); mixed, diluted, and cold	1, 2, 3	26	13	61	.00	.66	.00	.16	7.66	20.66	62.00	.00	.83
21	Copper ferrocyanide arsenate of lead (2-2-4-100); mixed, diluted, and cold	1, 2, 3	47	24	29	.00	.00	.00	.10	.60	7.90	10.80	.10	.10
Check B	No treatment	None	20	15	65	.33	1.08	.50	4.50	3.66	12.75	57.33	.00	.41

RELATIVE VALUES OF VARIOUS STRENGTHS OF LIME SULFUR

In order to determine the efficiencies of various strengths of lime sulfur, plats were sprayed as shown in Table 20.

EFFECT ON FOLIAGE

The foliage of all the sprayed plats was free from scab during the entire season. There was, however, a slight infection of frog-eye fungus. Plat 10 showed foliage injury to an extent indicating that one part of commercial concentrated lime sulfur in twelve of spray was too strong a solution. Aside from this, the foliage of all the plats was vigorous and of good color.

EFFECT ON FRUIT

The apples from these plats were picked and examined October 3 to 6. The results are given in Table 20. The fruit from the sprayed plats was entirely free from scab and sooty blotch. Codling moth entering at the calyx was well controlled, but the control of late-brood codling moth was inconsistent and unsatisfactory, owing to the fact that no late sprays were applied. Injury from curculio was greatly reduced by all the sprays. Plats 10 and 11 had a small percentage of russet; the remaining plats were practically free from it.

The fruit from these plats took on a high color and a waxy finish, and was of good size. Here again, as in the experiments at Griggsville in 1912, was illustrated the stimulating effect of lime sulfur arsenate of lead in improving the color and finish of the fruit.[1]

FUNGICIDAL AND INSECTICIDAL VALUES OF COPPER FERROCYANIDE MADE IN DIFFERENT WAYS

Copper ferrocyanide made according to the full and equal dilution method, with 2 pounds of copper sulfate and 2 pounds of potassium ferrocyanide in 100 gallons of spray, proved useless as a fungicide and insecticide in 1912, in the experiments at Griggsville. In 1913 it was decided to test this spray when prepared by other methods. Accordingly several plats were sprayed with copper ferrocyanide, alone and in combination with arsenate of lead, prepared as shown in Table 21.

EFFECT ON FOLIAGE

The foliage of all the sprayed plats was free from scab during the entire season. That of Plats 19, 20, and 21 was more vigorous and of a darker green than that of Plats 16, 17, and 18. This difference may have been due to an invigorating effect exercised by the arsenate

[1] J. C. Blair et al., Ill. Agr. Exp. Sta. Bul. 185, p. 186.

of lead. All plats had a small amount of spray injury in the form of small, brown spots. Insect work on Plats 16, 17, and 18 was greater than on the other plats, where arsenate of lead was added to the sprays. A slight infection of frog-eye fungus was present on all these plats.

EFFECT ON FRUIT

The apples from these plats were picked and examined October 6 and 7. The results are given in Table 21. The fungous infection of the unsprayed apples was so small that the differences favoring the various sprayed plats are not believed to be significant enough to warrant drawing conclusions on the effectiveness of copper-ferrocyanide sprays as fungicides. As insecticides they proved wholly worthless when used without arsenate of lead. The color of the fruit sprayed with copper ferrocyanide alone was decidedly less attractive than that of the fruit sprayed with copper ferrocyanide and arsenate of lead. The general results of the experiment are considered unfavorable to the use of copper ferrocyanide when made by any of the methods here used.

RELATIVE VALUES OF PROPRIETARY LIME-SULFUR COMPOUNDS

Thomsen atomic sulfur, Niagara soluble sulfur, and lime sulfur were tested and compared as shown by the treatments indicated in Table 22.

EFFECT ON FOLIAGE

The foliage of the sprayed plats was free from any infection of scab or other fungi during the entire season. Plats 22 and 24 had a very vigorous dark green foliage, free from spray injury. The foliage of Plat 23, however, sprayed with Niagara soluble sulfur, developed a severe tip and edge burning a few days after both the second and the third application, and as a consequence was scanty the rest of the season.

EFFECT ON FRUIT

The apples from these plats were picked and examined October 7, 8, and 9. The results are given in Table 22. The fruit from these plats was practically free from scab and sooty blotch. In comparing the sprayed plats with the check plat, it will be seen that the sprays materially reduced codling-moth and curculio injuries. Neither Thomsen atomic sulfur nor Niagara soluble sulfur caused any russeting of the fruit. The plat sprayed with lime sulfur showed 2 percent serious and 6.16 percent slight russet.

TABLE 22.—EFFECTS OF THOMSEN ATOMIC SULFUR, NIAGARA SOLUBLE SULFUR, AND GRASSELLI LIME SULFUR IN COMBINATION WITH ARSENATE OF LEAD, IN THE EXPERIMENTS AT GRIGGSVILLE, 1913

Plat	Treatment	Applications	Percentage grades of picked apples			Percentage of picked apples affected by—								
						Scab		Sooty blotch		Codling moth		Curculio	Russet	
			No. 1	No. 2	Culls	Serious	Slight	Serious	Slight	Calyx	Side	Serious	Serious	Slight
22	Thomsen atomic sulfur arsenate of lead (14-4-100)	1, 2, 3	42	28	30	.00	.00	.0	.12	.12	6.75	6.75	0	.00
23	Niagara soluble sulfur arsenate of lead (4-4-100)	1, 2, 3	56	22	22	.00	.00	.0	.10	.10	3.10	6.20	0	.20
24	Grasselli lime sulfur arsenate of lead (3-4-100)	1, 2, 3	48	19	33	.00	.16	.0	.00	.66	6.50	12.66	2	6.16
Check B	No treatment	None	20	15	65	.33	1.08	.5	4.50	3.66	12.75	57.33	0	.41

TABLE 23.—EFFECTS OF LIGHT AND HEAVY APPLICATIONS OF LIME SULFUR ARSENATE OF LEAD AND BORDEAUX ARSENATE OF LEAD IN THE EXPERIMENTS AT GRIGGSVILLE, 1913

Plat	Treatment	Applications	Percentage grades of picked apples			Percentage of picked apples affected by—								
						Scab		Sooty blotch		Codling moth		Curculio	Russet	
			No. 1	No. 2	Culls	Serious	Slight	Serious	Slight	Calyx	Side	Serious	Serious	Slight
25	Bordeaux arsenate of lead (light)	1, 2, 3	22	13	65	.00	.00	.0	.0	2.62	20.82	39.25	26.00	56.37
26	Bordeaux arsenate of lead (heavy)	1, 2, 3	20	15	65	.00	.00	.0	.0	1.00	11.87	33.25	68.25	28.60
27	Lime sulfur arsenate of lead (light)	1, 2, 3	34	28	38	.00	.00	.0	.0	.00	6.75	23.00	.25	2.00
28	Lime sulfur arsenate of lead (heavy)	1, 2, 3	37	20	43	.00	.00	.0	.0	.16	6.50	33.83	.66	6.00
Check B	No treatment	None	20	15	65	.33	1.08	.5	4.5	3.66	12.75	57.33	.00	.41

RELATIVE VALUES OF LIGHT AND HEAVY APPLICATIONS OF BORDEAUX ARSENATE OF LEAD AND LIME SULFUR ARSENATE OF LEAD

To determine the relative values of light and heavy sprayings of Bordeaux arsenate of lead and lime sulfur arsenate of lead, four plats were sprayed with these materials as shown in Table 23.

EFFECT ON FOLIAGE

The foliage on the sprayed plats was free from scab but showed a little frog-eye fungus. Late in the season Plats 25 and 26 suffered somewhat from a spray injury which took the form of brown spots. Plats 27 and 28 had healthy foliage and were free from spray injury.

EFFECT ON FRUIT

The apples from these plats were picked and examined October 9 and 10. The results are given in Table 23. The fruit from all the sprayed plats was entirely free from scab and sooty-blotch fungi. Plats 27 and 28, sprayed with lime sulfur arsenate of lead, showed almost perfect control of codling moth entering at the calyx, while Plats 25 and 26, sprayed with Bordeaux arsenate of lead, showed controls of 28 percent in the lightly sprayed plat and 73 percent in the heavily sprayed plat. The records of moths entering at the side of the apple are not considered significant because of the failure to apply sprays for the later broods. Curculio injury was reduced on all plats; in the case of the Bordeaux-sprayed plats, the reduction was larger on the heavily sprayed plat, while of the plats sprayed with lime sulfur, the reduction was inconsistently less on the heavily sprayed plat.

While no decided differences were shown between the effects of light and heavy applications in the control of fungi and insects, notable differences in the amounts of russet were observed. Heavy applications of Bordeaux seriously russeted 68.25 percent of the apples as compared with 26 percent seriously russeted by light applications. As the spray was applied with a hand pump at pressures not greater than 125 pounds, and as the same nozzles were used for both applications, the greater amount of russet can be attributed only to the greater amount of spray applied. Both of the plats sprayed with lime sulfur showed a negligible amount of russet.

SUMMARY OF RESULTS AT GRIGGSVILLE, 1913

1. Owing to the small amounts of apple scab, sooty blotch, and other fungi which appeared, it was impossible to obtain conclusive results as to the fungicidal values of the sprays used. Both Bordeaux

arsenate of lead and lime sulfur arsenate of lead gave practically complete control of scab and sooty blotch.

2. Three applications of Bordeaux arsenate of lead caused considerable foliage injury late in the season, and very seriously russeted, stunted, and distorted the fruit.

3. Lime sulfur arsenate of lead had an invigorating effect on foliage and a stimulating effect on the color and finish of the fruit.

4. Some russeting occurred as a result of single applications of Bordeaux arsenate of lead, applied either just before or two weeks after the bloom.

5. Powdered arsenate of lead gave as good results as the paste arsenate of lead.

6. Arsenate of lead used alone stimulated color and gave the fruit a good finish.

7. Various strengths of homemade lime sulfur, containing 2, 4, 6, 8, and 10 pounds of sulfur, together with 4 pounds of arsenate of lead to 100 gallons of spray, all gave satisfactory results. The 12-pound strength caused considerable injury to the foliage.

8. Copper ferrocyanide made in different ways proved useless as an insecticide when used alone.

9. Thomsen atomic sulfur arsenate of lead and Grasselli lime sulfur arsenate of lead gave equally good results in the control of fungi. Niagara soluble sulfur with arsenate of lead caused very serious foliage injury but gave highly colored fruit and satisfactorily controlled scab and sooty blotch.

10. Light spraying with Bordeaux, using 115 to 125 pounds pressure, caused less serious russet than heavy spraying at the same pressure.

11. Light and heavy spraying with lime sulfur arsenate of lead gave equally good results except in the control of curculio, for which light applications were more effective.

SPRAYING EXPERIMENTS IN 1914 AT GRIGGSVILLE, PIKE COUNTY

BY ALFRED J. GUNDERSON

OBJECTS

Spraying experiments were conducted at Griggsville, in 1914, to study the following points in summer spraying: (1) the relative values of lime sulfur and Bordeaux; (2) the value of interchanging lime sulfur and Bordeaux; (3) the value of a drenching spray, applied at the dropping of the petals, for the control of codling moth; (4) the relative values of light and heavy applications of lime sulfur arsenate of lead and Bordeaux arsenate of lead; (5) the relative values of light and heavy applications of lime sulfur arsenate of lead and Bordeaux arsenate of lead when used interchangeably; (6) the effect of reducing the strength of lime sulfur in the sprays following the second application; (7) the value of a fourth summer application; (8) the relative values of certain brands of arsenate of lead; (9) the relative values of certain proprietary lime-sulfur compounds; and (10) the fungicidal and insecticidal values of copper ferrocyanide with and without acetate of lead as an accelerating solvent.

LOCATION AND DESCRIPTION OF ORCHARD

The same block of trees was used in these experiments as that used in 1913, described on page 458. The arrangement of the plats is shown in Fig. 5, page 459.

APPARATUS AND MATERIALS

The sprays were applied with a Morrill and Morley Eclipse power sprayer at about 150 pounds pressure. Friend disc nozzles were used except for the second application on Plat 7, for which Bordeaux nozzles were used. Unless otherwise stated in the following tables, the sprays were prepared according to the methods described on pages 430 and 431.

WEATHER CONDITIONS

The weather from the middle of April thruout the summer was dry. During the fall, however, there were frequent rains. The temperature was exceptionally high during the summer months and early September.

Effect on Fungi.—The season was most unfavorable for fungous development. No scab infection appeared on any of the plats because of the dryness of the spring and early summer. Only a small amount of sooty blotch developed during the damp fall weather.

Effect on Codling Moth.—Under the hot, dry conditions prevailing during the summer, a second brood of codling moth appeared, and following it a partial third brood. Larvæ from this third brood began to enter the apples about the middle of September and continued doing damage up into picking time. In the experience of fruit growers at Griggsville an attack of third-brood codling moth had seldom, if ever, occurred, and most certainly never before in the history of the experimental work at that place. Consequently such an attack was not anticipated, and no sprays were applied against it. Sprays had been applied, however, against both the first and second broods, and these broods caused only slight damage. The third-brood moths, no doubt, came from a poorly sprayed part of the orchard not included in the experiments, in which large numbers of second-brood moths developed, producing a third brood that infested the experimental plats.

It is recognized that from 75 to 85 percent of first-brood codling moth enter the apples at the calyx end; hence the data in these experiments showing the number of larvæ entering thru the calyx would furnish an excellent criterion of the effectiveness of the sprays in controlling first-brood codling moths. Similarly, the number of larvæ entering thru the sides of the apples would, under normal conditions, furnish an excellent basis for a comparison of the effectiveness of sprays in controlling larvæ of the second-brood moths. Unfortunately, however, since the third-brood larvæ also enter thru the sides, and since the attack of this brood was more serious than that of the second brood, such comparative results as might have been observed from the effects of sprays on the second brood were largely obscured. While there are some small differences among the various plats in the number of moths entering thru the sides of the apples, these differences are not consistent nor large enough to be conclusive. In the case of the first brood, however, as indicated by the number entering thru the calyx, the results may be considered conclusive. Results showing the percentage of side injury done to apples by codling moth, tho given in the tables which follow, are not considered in the conclusions.

SPRAY DATES

All plats, with the exception of Plats 14 and 16, which were sprayed three times, received four summer applications. The dates of the applications were as follows: April 22 to 24, May 4 to 5, May 9 to 12, and July 8 to 10.

RELATIVE VALUES OF LIME SULFUR AND BORDEAUX

Experiments conducted at Griggsville during the previous three years showed lime sulfur and Bordeaux to be equally effective in the

control of fungi common to that locality. Furthermore, it was demonstrated that trees sprayed with lime sulfur arsenate of lead produced fruit of higher color and better finish and had better foliage than those sprayed with Bordeaux arsenate of lead. The effects of these two sprays were again compared in 1914, when two plats were treated as shown in Table 24.

EFFECT ON FOLIAGE

The leaves of the trees sprayed with lime sulfur arsenate of lead showed a slight amount of spray injury which appeared in the form of tip and edge burning. Spray injury caused by Bordeaux arsenate of lead appeared as small brown spots on the foliage. The foliage of the plat sprayed with lime sulfur arsenate of lead was denser and more vigorous than that of the plat sprayed with Bordeaux arsenate of lead, which suffered from frequent epidemics of yellow-leaf.

EFFECT ON FRUIT

The apples from these plats were picked and examined October 12, with the results presented in Table 24. These data show that, while the unsprayed fruit had 1.75 percent serious and 23.25 percent slight sooty blotch, both Bordeaux arsenate of lead and lime sulfur arsenate of lead completely controlled the infection. Sooty blotch was confined entirely to the unsprayed fruit hanging near the ground and was due to frequent fall rains, which created favorable conditions for the development of this disease. The unsprayed fruit had 10.25 percent calyx injury caused by first-brood codling moth; Plat 2, sprayed with lime sulfur arsenate of lead, had .75 percent of this injury; and Plat 1, sprayed with Bordeaux arsenate of lead, 1.25 percent. The check plat showed 23.25 percent serious curculio injury as compared with 6.75 percent on Plat 1 and 4.5 percent on Plat 2.

A marked difference in the effects of the two sprays upon the fruit is shown in the russet columns. Plat 1, sprayed with Bordeaux arsenate of lead, showed 24.75 percent serious and 61 percent slight russet, as compared with .25 percent serious and 3 percent slight russet on Plat 2, sprayed with lime sulfur arsenate of lead. Reference to the amount of russet on the unsprayed row will show that 1.25 percent serious and 2.25 percent slight russet may have been caused by something other than the sprays. Since these amounts were present on the unsprayed trees, the indications are that lime sulfur arsenate of lead was not responsible for the russet recorded. By the same reasoning it would also appear that 23.5 percent serious and 58.75 percent slight russet in Plat 1 was caused by Bordeaux.

The apples from the plat sprayed with lime sulfur arsenate of lead were the only ones affected by burning. This injury followed within two days after the fourth application, which was made July 8.

The temperature at the time of this application was 99° F. When first noticed the injury appeared as black, sunken areas the size of a half dollar, and was confined to fruit on certain limbs. Tho it seemed then that considerable injury had been done, by picking time only a small percentage of the fruit showed the effect of burning.

Heavy applications of lime sulfur arsenate of lead applied as late as July and August are usually followed by burning, especially if the weather is very warm. The absence of the pubescence characteristic of apples earlier in the season permits the spray to run together over the smooth surface of the apples and collect in one spot. The material so collected dries quickly in hot sunlight and becomes so caustic that injury to the skin results. Heavy spraying has been safely done, however, as late as three weeks following the bloom, even during hot weather. The absence of any resulting injury was in all probability due to the pubescent condition of the fruit. Plat 2 was sprayed thoroly but not heavily early in July. In spite of the care exerted, some of the fruit received more material than was intended and some burn resulted.

Plat 2, sprayed with lime sulfur arsenate of lead, had 65 percent No. 1's as compared with 51 percent in Plat 1, which was sprayed with Bordeaux arsenate of lead. Bordeaux russet was responsible for most of the difference. The apples sprayed with Bordeaux arsenate of lead were poorly colored and had a rough finish, while those sprayed with lime sulfur arsenate of lead were highly colored, smooth, and waxy.

VALUE OF INTERCHANGING LIME SULFUR AND BORDEAUX AS SUMMER SPRAYS

In order to obtain additional information on the value of interchanging lime sulfur and Bordeaux as summer sprays, plats were sprayed as shown in Table 25.

EFFECT ON FOLIAGE

The foliage of Plats 3, 4, and 5 showed a small amount of spray injury in the form of brown spots caused by the Bordeaux and as tip and edge burning caused by the lime sulfur. All three plats suffered from an attack of yellow-leaf which slightly reduced the amount of foliage.

EFFECT ON FRUIT

The apples from these plats were picked and examined October 12, with the results presented in Table 25. Sooty blotch was perfectly controlled by all the sprays. Calyx injury from codling moth was materially reduced on all plats. The unsprayed row showed 23.25 per-

TABLE 24.—EFFECTS OF BORDEAUX AND LIME SULFUR IN COMBINATION WITH ARSENATE OF LEAD, IN THE EXPERIMENTS AT GRIGGSVILLE, 1914

Plat	Treatment	Applications	Picked apples					Percentage of picked apples affected by—								
			Total No.	Total bu.	Percentage grades			Sooty blotch		Codling moth		Curculio	Russet		Burn	
					No. 1	No. 2	Culls	Serious	Slight	Calyx	Side	Serious	Serious	Slight	Serious	Slight
1	Bordeaux arsenate of lead	1, 2, 3, 4	1821	10.3	51	21	28	.00	.00	1.25	13.00	6.75	24.75	61.00	.00	.00
2	Lime sulfur arsenate of lead	1, 2, 3, 4	3456	21.8	65	16	19	.00	.00	.75	5.50	4.50	.25	3.00	.75	1.75
Check A	No treatment	None	1918	14.1	50	8	42	1.75	23.25	10.25	21.25	23.25	1.25	2.25	.00	.00

TABLE 25.—EFFECTS OF USING BORDEAUX FOR SOME APPLICATIONS AND LIME SULFUR FOR OTHER APPLICATIONS, IN THE EXPERIMENTS AT GRIGGSVILLE, 1914

Plat	Treatment	Applications	Picked apples					Percentage of picked apples affected by—								
			Total No.	Total bu.	Percentage grades			Sooty blotch		Codling moth		Curculio	Russet		Burn	
					No. 1	No. 2	Culls	Serious	Slight	Calyx	Side	Serious	Serious	Slight	Serious	Slight
1	Bordeaux arsenate of lead	1, 2, 3, 4	1821	10.3	51	21	28	.00	.00	1.25	13.00	6.75	24.75	61.00	.00	.00
2	Lime sulfur arsenate of lead	1, 2, 3, 4	3456	21.8	65	16	19	.00	.00	.75	5.50	4.50	.25	3.00	.75	1.75
3	Bordeaux arsenate of lead Lime sulfur arsenate of lead	1, 4 2, 3	2160	13.7	70	14	16	.00	.00	.50	8.50	4.75	2.00	19.50	.00	.00
4	Lime sulfur arsenate of lead Bordeaux arsenate of lead	1, 2, 3 4	2731	16.3	70	16	14	.00	.00	.25	7.75	2.75	.75	2.75	.00	.00
5	Bordeaux arsenate of lead Lime sulfur arsenate of lead	1 2, 3, 4	2749	18.2	67	15	18	.00	.00	.25	12.50	2.25	3.25	19.25	7.00	3.00
Check A	No treatment	None	1918	14.1	50	8	42	1.75	23.25	10.25	21.25	23.25	1.25	2.25	.00	.00

cent serious injury from curculio, but this, too, was effectively reduced on the sprayed plats.

As in the preceding experiment, important differences are brought out in the russet columns. The unsprayed row showed 1.25 percent serious and 2.25 percent slight russet. By subtracting these percentages from those reported under the various treatments, it will be seen that in Plat 5 Bordeaux applied at the cluster-bud stage caused 2 percent serious and 17 percent slight russet; Bordeaux applied to Plat 4 early in July caused practically no russet; and the Bordeaux applied to Plat 3 at the cluster-bud stage and again early in July caused .75 percent serious and 17.25 percent slight russet. Bordeaux, then, russeted the fruit when applied just before the bloom, but not when applied as late as July 8, more than two months after the bloom.

Plat 5 showed 7 percent serious and 3 percent slight burn. This followed applications of lime sulfur arsenate of lead made July 8 with the temperature at 99° F. and above.

Plats 2, 3, 4, and 5 had good percentages of No. 1 apples. The apples from Plats 3 and 5 had a rough finish due to slight russet, but showed fair color, while those from Plat 4 had better color and finish. It was clearly demonstrated, from the appearance of the fruit on the trees, that the less frequently Bordeaux arsenate of lead was used before July 1, the better the color and finish of the apples.

VALUE OF A DRENCHING SPRAY, APPLIED AT THE DROPPING OF THE PETALS, FOR THE CONTROL OF CODLING MOTH

Early in the spring an Illinois apple grower requested that further tests be made of the value of a drenching spray applied at the dropping of the petals for the control of codling moth. In the following experiment this method was tested and compared with an ordinary thoro spraying. The spray schedule for the plats thus treated is shown in Table 26. Bordeaux nozzles were used for the drenching spray and Friend disc nozzles for the ordinary thoro spraying.

EFFECT ON FOLIAGE

With the exception of a slight amount of spray injury, the foliage of both sprayed plats was good.

EFFECT ON FRUIT

The fruit from these plats was picked and examined October 13 and 14, with the results presented in Table 26. Plats 7 and 3 were entirely free from sooty blotch. Plat 7 showed 5.5 percent calyx injury from codling moth as compared with .5 percent of the same injury on Plat 3 and 10.25 percent on the unsprayed row. The greater infestation of codling moth on Plat 7, where the drenching spray was

TABLE 26.—EFFECTS OF A DRENCHING SPRAY APPLIED FOR CODLING MOTH IMMEDIATELY AFTER THE FALL OF THE PETALS, IN THE EXPERIMENTS AT GRIGGSVILLE, 1914

Plat	Treatment	Applications	Picked apples					Percentage of picked apples affected by—								
			Total No.	Total bu.	Percentage grades			Sooty blotch		Codling moth		Curculio	Russet		Burn	
					No. 1	No. 2	Culls	Serious	Slight	Calyx	Side	Serious	Serious	Slight	Serious	Slight
7	Bordeaux arsenate of lead ... Lime sulfur arsenate of lead (drenching spray) Lime sulfur arsenate of lead..	1, 4 2 3	2234	14.5	69	11	20	.00	.00	5.50	20.25	.75	.50	24.00	0	0
3	Bordeaux arsenate of lead ... Lime sulfur arsenate of lead (ordinary thoro spray) .. Lime sulfur arsenate of lead..	1, 4 2 3	2160	13.7	70	14	16	.00	.00	.50	8.50	4.75	2.00	19.50	0	0
Check A	No treatment	None	1918	14.1	50	8	42	1.75	23.25	10.25	21.25	23.25	1.25	2.25	0	0

TABLE 27.—EFFECTS OF LIGHT AND HEAVY APPLICATIONS OF BORDEAUX AND LIME SULFUR, IN THE EXPERIMENTS AT GRIGGSVILLE, 1914

Plat	Treatment	Applications	Picked apples					Percentage of picked apples affected by—								
			Total No.	Total bu.	Percentage grades			Sooty blotch		Codling moth		Curculio	Russet		Burn	
					No. 1	No. 2	Culls	Serious	Slight	Calyx	Side	Serious	Serious	Slight	Serious	Slight
8	Bordeaux arsenate of lead (heavy).....	1, 2, 3, 4	1556	9.8	62	14	24	.00	.00	1.00	23.00	1.00	31.50	64.00	0	.00
11	Bordeaux arsenate of lead (light).....	1, 2, 3, 4	1739	12.8	72	11	17	.00	.00	1.25	11.75	3.00	3.25	51.00	0	.00
9	Lime sulfur arsenate of lead (heavy).....	1, 2, 3, 4	1265	10.2	71	7	22	.00	.00	.25	17.50	1.25	1.25	1.25	12	6.75
12	Lime sulfur arsenate of lead (light).....	1, 2, 3, 4	2159	14.8	77	9	14	.00	.00	.75	13.00	1.25	.75	3.00	4	3.00
Check A	No treatment.....	None	1918	14.1	50	8	42	1.75	23.25	10.25	21.25	23.25	1.25	2.25	0	.00

used, may have been due to the ineffectiveness of the spray, which was applied at the dropping of the petals and for which Bordeaux nozzles were used. The pressure was less than 100 pounds, while in the case of Plat 3, sprayed at the same time but with Friend nozzles, the pressure remained at 150 pounds. The low pressure and the coarse spray resulting from the use of the Bordeaux nozzles may have prevented proper penetration into the calyx ends of the apples. The drenching spray, however, proved more effective in the control of curculio. While the infestation was greatly reduced by both sprays, the injury from this insect in Plat 7 was negligible.

In the preceding experiment it was shown that while Bordeaux applied at the cluster-bud stage caused russet, no such injury resulted from applications made early in July. By subtracting the amount of russet recorded for the check trees from that recorded for Plats 7 and 3, it is again shown that some russeting may result from an application of Bordeaux applied just before the bloom. The color of the fruit from both plats was good, but the finish was somewhat rough on account of a slight russet.

RELATIVE VALUES OF LIGHT AND HEAVY APPLICATIONS OF LIME SULFUR ARSENATE OF LEAD AND BORDEAUX ARSENATE OF LEAD

The relative values of light and heavy spraying with lime sulfur arsenate of lead and Bordeaux arsenate of lead were tested on plats which were sprayed as shown in Table 27.

EFFECT ON FOLIAGE

The foliage of Plat 8, sprayed heavily with Bordeaux arsenate of lead, was reduced considerably by spray injury and by two epidemics of yellow-leaf. Plat 9, receiving heavy applications of lime sulfur arsenate of lead, showed considerable tip and edge burning. Plats 11 and 12, on the other hand, receiving light applications of Bordeaux arsenate of lead and lime sulfur arsenate of lead, respectively, showed very little spray injury and had excellent foliage.

EFFECT ON FRUIT

The fruit from these plats was picked and examined October 14 and 15, with the results presented in Table 27. Sooty blotch was completely controlled by all the sprays. Calyx injury from codling moth was practically the same for all four plats; a considerable reduction from the injury recorded for the unsprayed row was shown. Curculio injury was effectively and almost equally reduced on all the plats in this group.

When the russet percentages of the check plat are subtracted from the percentages of Plats 8 and 11, it is shown that the Bordeaux

caused 30.25 percent serious and 61.75 percent slight russet on Plat 8, and 2 percent serious and 48.75 percent slight russet on Plat 11. Since all the sprays on both plats were applied at about 150 pounds pressure and under the same conditions, these results indicate that the amount and the severity of the russet depended upon the quantity of Bordeaux used. Deducting the amount of russet recorded for the unsprayed plat from that recorded for Plats 9 and 12, shows that the lime sulfur arsenate of lead used in these plats caused no russet.

The percentage of burn caused by the lime sulfur arsenate of lead was greater where the heavier applications were made. The fact that the burn occurred on both plats soon after the fourth spray, applied early in July during very hot weather, would indicate that if lime sulfur is applied either heavily or lightly late in the season when the temperature is near 100° F., some burning will result. The amount of burning will depend upon the quantity of material applied. Spraying so as not to permit the material to collect in drops seems to be the best way to avoid this burn.

Plat 12 had the highest percentage of No. 1 apples; the percentages of Plats 9 and 11 were almost as high and practically equal. In Plat 8 the percentage was reduced by the serious russet present. The fruit from Plats 9 and 12 had excellent color and finish, while that from Plats 8 and 11, because of russet, lacked these qualities.

Relative Values of Light and Heavy Applications of Lime Sulfur Arsenate of Lead and Bordeaux Arsenate of Lead Used Interchangeably

The relative values of light and heavy applications of lime sulfur arsenate of lead and Bordeaux arsenate of lead when used interchangeably were tested on two plats treated as shown in Table 28.

EFFECT ON FOLIAGE

Both plats showed some spray injury, Plat 10, which received the heavy spraying, having slightly more than Plat 13.

EFFECT ON FRUIT

The fruit from these plats was picked and examined October 14 and 15, with the results presented in Table 28. Both plats were entirely free from sooty blotch. Curculio and codling-moth injuries were slightly greater on Plat 13 than on Plat 10, altho damage from both insects was materially reduced on these plats, as shown by comparison with that on the unsprayed row.

According to results obtained by subtracting the percentages for the check plat from those for the sprayed plats, Plat 10 had 4.75 percent serious and 19.25 percent slight russet, and Plat 13 had 11.75

percent slight russet caused by the sprays. It is evident here, as in the preceding experiment, that the amount and severity of the russet were regulated by the amount of spray applied, since all the applications were made at the same pressure.

The effect of the different treatments is not brought out in the grade columns, where the percentages are practically the same for both plats. The color of the fruit from these plats was good, but finish was lacking because of russet.

EFFECT OF GRADUALLY REDUCING THE STRENGTH OF LIME SULFUR AFTER THE SECOND APPLICATION

The effects of gradually reducing the strength of the lime sulfur in applications of lime sulfur arsenate of lead, following the second spraying, were tested as shown in Table 29. These were compared in turn with the effects of lime sulfur used at the same strength thruout the season in combination with arsenate of lead.

EFFECT ON FOLIAGE

The foliage of both sprayed plats showed some lime-sulfur injury in the form of tip and edge burning; otherwise the foliage was good.

EFFECT ON FRUIT

The fruit from these plats was picked and examined October 12 and 13, with the results presented in Table 29. Both sprayed plats were entirely free from sooty blotch. Codling-moth calyx injury was almost equally well controlled by both sprays. Curculio was more effectively controlled on Plat 6, where different strengths of lime sulfur were used, than on Plat 2, where the same strength was used thruout the season. Both treatments, however, greatly reduced curculio infestation, as is indicated by the infestation on the unsprayed row. The russet shown on Plats 2 and 6 could not have been caused by the spray, because practically the same amount was present on the unsprayed apples. The amount of burn, which was small, was practically equal on both plats. This injury followed soon after the fourth application, made early in July on an extremely warm day. In spite of the care taken to spray the trees thoroly but not heavily, a few branches received too much spray, and the fruit on these suffered from burn. The percentage of No. 1 apples was greater on Plat 6 than on Plat 2. The fruit of both plats had excellent color and finish.

VALUE OF A FOURTH SUMMER APPLICATION

With the object of determining the value of a fourth summer application, four plats were sprayed as shown in Table 30.

TABLE 28.—EFFECTS OF LIGHT AND HEAVY APPLICATIONS OF BORDEAUX AND LIME SULFUR WHERE BOTH WERE USED IN THE SAME SPRAY SCHEDULE, IN THE EXPERIMENTS AT GRIGGSVILLE, 1914

Plat	Treatment	Applications	Picked apples					Percentage of picked apples affected by—								
			Total No.	Total bu.	Percentage grades			Sooty blotch		Codling moth		Curculio	Russet		Burn	
					No. 1	No. 2	Culls	Serious	Slight	Calyx	Side	Serious	Serious	Slight	Serious	Slight
10	Bordeaux arsenate of lead (heavy)	1, 4														
	Lime sulfur arsenate of lead (heavy)	2, 3	1409	10.3	77	9	14	.00	.00	2.25	12.75	1.00	6.00	21.50	0	0
13	Bordeaux arsenate of lead (light)	1, 4														
	Lime sulfur arsenate of lead (light)	2, 3	1858	14.1	75	9	16	.00	.00	3.00	15.25	4.75	.75	14.00	0	0
Check A	No treatment	None	1918	14.1	50	8	42	1.75	23.25	10.25	21.25	23.25	1.25	2.25	0	0

TABLE 29.—EFFECTS OF GRADUALLY REDUCING THE STRENGTH OF LIME SULFUR AFTER THE SECOND APPLICATION, IN THE EXPERIMENTS AT GRIGGSVILLE, 1914

Plat	Treatment	Applications	Picked apples					Percentage of picked apples affected by—								
			Total No.	Total bu.	Percentage grades			Sooty blotch		Codling moth		Curculio	Russet		Burn	
					No. 1	No. 2	Culls	Serious	Slight	Calyx	Side	Serious	Serious	Slight	Serious	Slight
2	Lime sulfur arsenate of lead (1 in 20)	1, 2, 3, 4	3456	21.8	65	16	19	.00	.00	.75	5.50	4.50	.25	3.00	.75	1.75
6	Lime sulfur arsenate of lead (1 in 20)	1, 2														
	Lime sulfur arsenate of lead (1 in 40)	3														
	Lime sulfur arsenate of lead (1 in 50)	4	2331	15.1	71	14	15	.00	.00	1.25	11.25	1.00	1.50	.50	1.00	1.25
Check A	No treatment	None	1918	14.1	50	8	42	1.75	23.25	10.25	21.25	23.25	1.25	2.25	.00	.00

TABLE 30.—EFFECTS OF A FOURTH SUMMER APPLICATION, IN THE EXPERIMENTS AT GRIGGSVILLE, 1914

Plat	Treatment	Applications	Picked apples					Percentage of picked apples affected by—								
			Total No.	Total bu.	Percentage grades			Sooty blotch		Codling moth		Curculio	Russet		Burn	
					No. 1	No. 2	Culls	Serious	Slight	Calyx	Side	Serious	Serious	Slight	Serious	Slight
2	Lime sulfur arsenate of lead	1, 2, 3, 4	3456	21.8	65	16	19	.00	.00	.75	5.50	4.50	.25	3.00	.75	1.75
16	Lime sulfur arsenate of lead	1, 2, 3	2171	16.8	80	6	14	.00	.00	1.00	12.25	2.75	.25	1.00	.00	.00
3	Bordeaux arsenate of lead	1, 4														
	Lime sulfur arsenate of lead	2, 3	2160	13.7	70	14	16	.00	.00	.50	8.50	4.75	2.00	19.50	.00	.00
14	Bordeaux arsenate of lead	1														
	Lime sulfur arsenate of lead	2, 3	2302	16.4	71	11	18	.00	.00	.00	18.75	3.00	3.25	16.50	.00	.00
Check A	No treatment	None	1918	14.1	50	8	42	1.75	23.25	10.25	21.25	23.25	1.25	2.25	.00	.00

EFFECT ON FOLIAGE

The foliage of Plats 14 and 16, which did not receive a fourth application, was practically free from spray injury, while that of Plat 2 showed some injury caused by the fourth application. So far as the foliage was concerned the fourth application of Bordeaux arsenate of lead and lime sulfur arsenate of lead did more harm than good.

EFFECT ON FRUIT

The fruit from these plats was picked and examined October 12 and 19, with the results presented in Table 30. Sooty blotch was completely controlled on all plats. Codling-moth calyx injury was completely controlled on Plat 14 and effectively controlled on the other sprayed plats. Curculio infestation was also effectively reduced.

Comparison of the russet percentages of the sprayed plats with those of the check plat shows that the russet on Plats 2 and 16 was caused by something other than the sprays. Plat 3, however, had .75 percent serious and 17.25 percent slight russet, and Plat 14 had 2 percent serious and 14.25 percent slight russet caused by the Bordeaux. It has been previously stated that Bordeaux does not russet fruit when applied as late in the season as July. Since the amount of russet on Plats 3 and 14 is practically equal, it is again shown that the fourth spray of Bordeaux did not cause russet.

Plat 2, which received four applications of lime sulfur arsenate of lead, had .75 percent serious and 1.75 percent slight burn. Since no burn was found on the fruit of Plat 16, which received only three sprays of this material, the injury on Plat 2 must have resulted from the fourth application, made in July.

All four sprayed plats had a good percentage of No. 1 apples. The fruit from Plats 2 and 16 had better color and finish than that from Plats 3 and 14, because of the absence of Bordeaux russet.

These experiments showed that a fourth application of Bordeaux arsenate of lead was of no value; that a fourth application of lime sulfur arsenate of lead caused burn; and that three applications of lime sulfur arsenate of lead gave equally good results in controlling sooty blotch and caused no injury to the fruit.

RELATIVE VALUES OF CERTAIN BRANDS OF ARSENATE OF LEAD

In this experiment certain brands of arsenate of lead were tested on plats treated as shown in Table 31.

EFFECT ON FOLIAGE

The foliage of these plats showed some burning caused by Bordeaux and lime sulfur arsenate of lead.

Plat	Treatment	Applications	Picked apples: Total No.	Picked apples: Total bu.	Picked apples: Percentage grades: No. 1	Picked apples: Percentage grades: No. 2	Picked apples: Percentage grades: Culls	Percentage of picked apples affected by: Sooty blotch: Serious	Sooty blotch: Slight	Codling moth: Calyx	Codling moth: Side	Curculio: Serious	Russet: Serious	Russet: Slight	Burn: Serious	Burn: Slight
3	Bordeaux Grasselli paste arsenate of lead (4-100)	1, 4														
	Lime sulfur Grasselli paste arsenate of lead (4-100)	2, 3	2160	13.7	70	14	16	.0	0	.50	8.50	4.75	2.00	19.50	0	0
17	Bordeaux Corona powdered arsenate of lead (2-100)	1, 4														
	Lime sulfur Corona powdered arsenate of lead (2-100)	2, 3	2111	15.0	79	11	10	.0	0	.25	11.00	3.00	4.25	20.25	0	0
18	Bordeaux Corona powdered arsenate of lead (4-100)	1, 4														
	Lime sulfur Corona powdered arsenate of lead (4-100)	2, 3	2380	19.0	80	10	10	.0	0	1.00	10.25	5.00	3.00	21.50	0	0
19	Bordeaux Ansbacher paste arsenate of lead (4-100)	1, 4														
	Lime sulfur Ansbacher paste arsenate of lead (4-100)	2, 3	2206	15.8	78	10	12	.0	0	.25	15.00	3.50	2.00	18.50	0	0
20	Bordeaux Dow paste arsenate of lead (4-100)	1, 4														
	Lime sulfur Dow paste arsenate of lead (4-100)	2, 3	1380	11.1	69	10	21	.0	0	1.75	17.25	10.00	4.00	17.75	0	0
21	Bordeaux Sherwin-Williams paste arsenate of lead (4-100)	1, 4														
	Lime sulfur Sherwin-Williams paste arsenate of lead (4-100)	2, 3	1511	11.9	52	12	36	.0	0	2.75	35.75	12.00	3.75	20.75	0	0
22	Bordeaux Sherwin-Williams powdered arsenate of lead (2-100)	1, 4														
	Lime sulfur Sherwin-Williams powdered arsenate of lead (2-100)	2, 3	2303	17.3	66	9	25	.0	0	.00	25.25	9.50	2.25	15.75	0	0
23	Bordeaux Thomsen paste arsenate of lead (4-100)	1, 4														
	Lime sulfur Thomsen paste arsenate of lead (4-100)	2, 3	2401	15.6	70	12	18	.0	0	.25	17.50	6.75	4.00	23.75	0	0
Check B	No treatment	None	972	7.7	33	8	59	.5	8	11.50	36.50	33.75	1.00	2.00	0	0

EFFECT ON FRUIT

The fruit from these plats was picked and examined October 19 and 20. As shown in Table 31, the fruit of the sprayed plats was entirely free from sooty blotch. The unsprayed row showed 11.5 percent codling-moth calyx injury. Grasselli paste arsenate of lead (4-100) reduced this injury to .5 percent; Corona powdered arsenate of lead (2-100) to .25 percent; Corona powdered arsenate of lead (4-100) to 1 percent; Ansbacher paste arsenate of lead (4-100) to .25 percent; Dow paste arsenate of lead (4-100) to 1.75 percent; Sherwin-Williams paste arsenate of lead (4-100) to 2.75 percent; Sherwin-Williams powdered arsenate of lead (2-100) controlled it completely; and Thomsen paste arsenate of lead (4-100) reduced it to .25 percent. All the arsenates of lead reduced curculio infestation.

All sprayed plats showed some russet from the first application of Bordeaux, but all, with the exception of Plat 21, had a good percentage of No. 1 apples. The apples in Plat 21 were most severely damaged by the partial third brood of codling moth. The color of the fruit was good on all plats, but the finish was rough.

RELATIVE VALUES OF CERTAIN PROPRIETARY LIME-SULFUR COMPOUNDS

The relative values of Niagara soluble sulfur, Thomsen atomic sulfur, and lime sulfur were tested as shown in Table 32.

EFFECT ON FOLIAGE

Lime sulfur arsenate of lead caused some tip and edge burning on the foliage of Plat 15. Injury from Niagara soluble sulfur arsenate of lead, together with an epidemic of yellow-leaf, reduced the amount of foliage in Plat 24. The foliage of Plat 25, sprayed with Thomsen atomic sulfur, was excellent; it showed but a negligible amount of tip and edge burning.

EFFECT ON FRUIT

The fruit from these plats was picked and examined October 19 and 21, with the results presented in Table 32. As in the preceding experiments, all the sprayed plats were entirely free from sooty blotch. Codling-moth calyx injury was reduced from 11.5 percent on the unsprayed row to .5 percent on Plat 15, .25 percent on Plat 24, and 1 percent on Plat 25. Considerable burning of the fruit occurred on Plat 15, and some on Plats 24 and 25. The injury in each case followed the fourth application, made during the hot weather of early July, and appeared only on the fruit of certain branches which had received a little too much spray. The fruit of all three plats possessed excellent color and finish. That of Plat 24, however, excelled all other fruit in the orchard with respect to color. A good percentage of No. 1 apples was obtained from each plat.

TABLE 32.—EFFECTS OF PROPRIETARY SULFUR SPRAYS, IN THE EXPERIMENTS AT GRIGGSVILLE, 1914

Plat	Treatment	Applications	Picked apples					Percentage of picked apples affected by—								
			Total No.	Total bu.	Percentage grades			Sooty blotch		Codling moth		Curculio	Russet		Burn	
					No. 1	No. 2	Culls	Serious	Slight	Calyx	Side	Serious	Serious	Slight	Serious	Slight
15	Grasselli lime sulfur arsenate of lead (2-4-100)	1, 2, 3, 4	2059	14.4	70	11	19	.0	0	.50	9.50	4.25	.75	2.00	9.50	9.00
24	Niagara soluble sulfur arsenate of lead (2-4-100)	1, 2, 3, 4	3013	19.4	75	11	14	.0	0	.25	6.75	3.50	.75	.25	3.50	2.75
25	Thomsen atomic sulfur arsenate of lead (14-4-100)	1, 2, 3, 4	2763	17.8	69	11	20	.0	0	1.00	10.75	2.75	1.75	1.50	2.25	2.50
Check B	No treatment	None	972	7.7	33	8	59	.5	8	11.50	36.50	33.75	1.00	2.00	.00	.00

TABLE 33.—EFFECTS OF COPPER FERROCYANIDE WITH AND WITHOUT ACETATE OF LEAD, IN THE EXPERIMENTS AT GRIGGSVILLE, 1914

Plat	Treatment	Applications	Picked apples					Percentage of picked apples affected by—								
			Total No.	Total bu.	Percentage grades			Sooty blotch		Codling moth		Curculio	Russet		Burn	
					No. 1	No. 2	Culls	Serious	Slight	Calyx	Side	Serious	Serious	Slight	Serious	Slight
26	Copper ferrocyanide arsenate of lead (2-2-4-100)	1, 2, 3, 4	1957	12.9	70	11	19	.0	0	1.25	16.25	5.25	2.00	2.0	0	0
27	Copper ferrocyanide acetate of lead arsenate of lead (2-2½-4-100)	1, 2, 3, 4	1840	12.5	64	12	24	.0	0	1.00	13.75	18.50	.75	.0	0	0
28	Copper ferrocyanide acetate of lead (2-2½-100)	1, 2, 3, 4	998	7.0	36	10	54	.0	0	7.50	38.75	24.00	.25	.5	0	0
Check B	No treatment	None	972	7.7	33	8	59	.5	8	11.50	36.50	33.75	1.00	2.0	0	0

FUNGICIDAL AND INSECTICIDAL VALUES OF COPPER FERROCYANIDE WITH AND WITHOUT ACETATE OF LEAD AS AN ACCELERATING SOLVENT

The results of past experiments with copper ferrocyanide showed it to be practically useless either as a fungicide or as an insecticide. This ineffectiveness may be explained by the fact that copper ferrocyanide is very insoluble. It was suggested that the addition of an accelerating solvent, such as acetate of lead, might make this compound sufficiently soluble to be effective. Accordingly, three plats were treated as shown in Table 33.

EFFECT ON FOLIAGE

The foliage of Plats 26 and 27 was by far the best in the orchard, from the standpoint of both color and size. The leaves possessed a dark green, velvety appearance. The foliage of Plat 28 was excellent but not equal to that of Plats 26 and 27.

EFFECT ON FRUIT

The fruit from these plats was picked and examined October 21 and 22, with the results presented in Table 33. The absence of sooty blotch in Plats 26, 27, and 28 may have been due to the fact that these plats were situated on higher and drier ground than the unsprayed trees. Codling-moth calyx injury was almost equally reduced on Plats 26 and 27 by the action of the arsenate of lead. On Plat 28, however, this injury was not much less than on the unsprayed row. Curculio injury was effectively reduced on Plat 26. The greater injury from this insect shown in Plat 27 may be explained by the fact that this plat was situated near a clump of woods and underbrush. It has been the experience of the writer that when even thoroly sprayed trees are situated in close proximity to a woods or a brush heap, they suffer more from curculio than those in the open. The sprays applied to Plat 28 reduced curculio infestation only slightly.

Plats 26 and 27 had fruit of higher color and better finish than did Plat 28, probably owing to the arsenate of lead in the sprays. Plats 26 and 27 far surpassed Plat 28 in the percentage of No. 1 apples. Plat 28 and the unsprayed row had about equal percentages.

SUMMARY OF RESULTS AT GRIGGSVILLE, 1914

1. Climatic conditions at Griggsville in 1914 were unfavorable to scab development but favorable to codling-moth infestation.

2. Codling-moth calyx injury was greatly reduced on all plats where arsenate of lead was used. Because of severe infestation from a partial third brood of this insect entering thru the sides of the apples just prior to picking time, the effectiveness of the sprays in controlling second-brood codling-moth larvæ was largely obscured.

3. Sooty-blotch infection was small; it was completely controlled.

4. Serious russeting of the fruit resulted from Bordeaux applied about a week after the bloom. Some russeting resulted from the cluster-bud application of the same material, but none from an application made early in July.

5. Both Bordeaux arsenate of lead and lime sulfur arsenate of lead caused foliage injury, the former causing more serious injury than the latter.

6. Lime sulfur arsenate of lead applied on hot days early in July caused some burn. Early applications, however, did not.

7. Apples sprayed with lime sulfur arsenate of lead had better finish and color than those sprayed with Bordeaux arsenate of lead.

8. Interchanging lime sulfur arsenate of lead and Bordeaux arsenate of lead, except when three applications of lime sulfur arsenate of lead were followed by one of Bordeaux arsenate of lead early in July, proved unsatisfactory, owing to the increased amount of russet.

9. A drenching spray under low pressure applied at the fall of the bloom proved unsatisfactory in the control of codling moth.

10. The severity and the amount of Bordeaux russet depended upon the quantity of spray used.

11. A heavy application of lime sulfur arsenate of lead applied early in July caused more serious burn than a light application applied at the same time. There was no difference in this respect between light and heavy applications made earlier in the season.

12. Heavy applications of lime sulfur arsenate of lead and of Bordeaux arsenate of lead used interchangeably proved less satisfactory than light applications made at the same times, owing to the better color and finish of the lightly sprayed fruit.

13. No particular advantage was gained by gradually reducing the strength of lime sulfur in the applications of lime sulfur arsenate of lead following the second spraying; 1-in-20 homemade lime sulfur caused practically the same amount of burn as 1-in-50 homemade lime sulfur when applied early in July.

14. Three applications of lime sulfur arsenate of lead proved more satisfactory than four applications of either lime sulfur arsenate of lead or Bordeaux arsenate of lead.

15. All brands of arsenate of lead tested reduced codling-moth injury effectively.

16. Niagara soluble sulfur, Grasselli lime sulfur, and Thomsen atomic sulfur combined with arsenate of lead caused some burning of the fruit when applied early in July. The soluble sulfur seriously injured the foliage; the other two sprays caused but slight injury.

17. No data were secured on the fungicidal value of copper ferrocyanide with and without acetate of lead. The data on the insecticidal value of this spray indicate that it is too slight in effect to be of commercial significance.

GENERAL SUMMARY

BY B. S. PICKETT

The field experiments in spraying in 1913 and 1914, having been performed with a view to solving certain definite problems, are summarized in the form of answers to specific questions suggested directly or indirectly by the general considerations discussed in the introduction to this bulletin.

SUMMARY OF DATA

1. *What is the general effectiveness of applications of standard spray mixtures, including Bordeaux, lime sulfur, and arsenate of lead, in the control of fungi and insects affecting the apple crop?*

In summarizing the data for the field experiments during the years 1909 to 1912,[1] the writer, in answering a similar question, made the following statement:

"No fact stands out more distinctly in a study of the data presented in the reports included in this bulletin than the general effectiveness of spraying over no spraying. Even under the most unfavorable circumstances, some degree of benefit has resulted from the application of all the standard sprays in every series of experiments and in every year of the experimentation. Year after year the sprayed plats have been conspicuous by their more healthy and vigorous foliage and by the freedom of their fruit from insects and diseases."

The data obtained in 1913 and 1914 add further evidence of the effectiveness of spraying, tho the comparative freedom of some of the orchards from fungi and of others from codling moth and curculio, in one or both seasons, has resulted in obtaining fewer records than had there been more generally severe infestations of insects and infections of fungi.

Tables 34 and 35 present a summary of all the data obtained in 1913 and 1914 which bear directly on the effectiveness of Bordeaux, lime sulfur, and arsenate of lead in controlling fungous diseases and insects. At a casual glance it will be seen that in nearly all cases high degrees of control of diseases and insects prevail. In interpreting the data, however, allowances must be made for the severity of the disease infection or the insect infestation, as the case may be. When such allowances are made, the advantages of spraying become even more marked than the controls in the tables indicate.

No data on the control of apple scab or other fungous diseases where either Bordeaux or lime sulfur with arsenate of lead were used were secured at Neoga or Flora. At Neoga, apple scab did not appear during 1913 and 1914, and at Flora no tests were made of either spray alone. At Griggsville, in 1913, there was a small infection of apple

[1] J. C. Blair et al., Ill. Agr. Exp. Sta. Bul. 185, p. 187.

Table[1]	Page	Experimenter	Place	Year	Fungicide[5]	Percentage of Scab		Percentage of Sooty blotch		Percentage of Blotch		Russet[6]	Burn[6]
						Infection	Control	Infection	Control	Infection	Control		
17	461	A. J. G.	Griggsville	1913	Bordeaux.....	2.33	100	22.74	100	.0		87.34	
19	464	A. J. G.	Griggsville	1913	Bordeaux.....	2.33	100	22.74	100	.0		85.24	
24	476	A. J. G.	Griggsville	1914	Bordeaux.....	.00		25.00	100	.0		82.25	.0
27	478	A. J. G.	Griggsville	1914	Bordeaux.....							50.75 to 92.0	.0
17	461	A. J. G.	Griggsville	1913	Lime sulfur....	2.33	100	22.74	100	.0		.39	.0
19	464	A. J. G.	Griggsville	1913	Lime sulfur....	2.33	100	22.74	100	.0		5.59	.0
20	464	A. J. G.	Griggsville	1913	Lime sulfur....	2.33	100	22.74	100	.0		0 to 5.61	.0
22	469	A. J. G.	Griggsville	1913	Lime sulfur....	1.41	89	5.00	100	.0		0 to 7.75	.0
24	476	A. J. G.	Griggsville	1914	Lime sulfur....	.00		25.00	100	.0		.0	2.5
30[2]	483	A. J. G.	Griggsville	1914	Lime sulfur....	.00		25.00	100	.0		.0	.0
32	487	A. J. G.	Griggsville	1914	Lime sulfur....	.00		8.50	100	.0		.0	18.5
11[3]	454	W. A. R.	Flora	1913	Lime sulfur and Bordeaux....	62.20	86 to 100	.00		56.6	43 to 93		
12[4]	454	W. A. R.	Flora	1913	Lime sulfur and Bordeaux....	34.90	93 to 99	.00		52.6	63 to 90		
18	461	A. J. G.	Griggsville	1913	Lime sulfur and Bordeaux....	2.33	100	22.74	95 to 100	.0			
25	476	A. J. G.	Griggsville	1914	Lime sulfur and Bordeaux....	.00		25.00	100	.0			
30[2]	483	A. J. G.	Griggsville	1914	Lime sulfur and Bordeaux....	.00		25.00	100	.0			
31	485	A. J. G.	Griggsville	1914	Lime sulfur and Bordeaux....	.00		8.50	100	.0			

[1]Data from Table 26 are omitted because Plat 3 is reported elsewhere and sprays were not applied to Plat 7 in standard quantities; from Table 27, with regard to scab, blotch, and sooty blotch, because applications were not made in standard quantities; from Table 28 because sprays were not applied in standard quantities; and from Table 29 because records for Plat 2 are presented in Table 24, and in Plat 6 standard dilutions were not followed.

[2]Data for Plats 2 and 3 are reported elsewhere, hence Plat 16 only is given here.

[3]Tables 13 and 15 present practically the same data and are therefore omitted.

[4]Tables 14 and 16 present practically the same data and are therefore omitted.

[5]Arsenate of lead was used with the fungicide in every case.

[6]Russet and burn data are omitted where both Bordeaux and lime sulfur were used owing to the fact that the amounts varied, depending on the arrangement of the schedule and the number of times each was used. Russet and burn data are obtained by subtracting the total russet or burn shown on the unsprayed plats from that shown on the sprayed plats in question.

TABLE 35.—EFFECTS OF ARSENATE OF LEAD USED ALONE AND IN COMBINATION WITH FUNGICIDES ON THE CONTROL OF CODLING MOTH AND CURCULIO, IN FIELD EXPERIMENTS IN SPRAYING, 1913 AND 1914

Table	Page	Experimenter	Place	Year	Percentage of—								
					Codling moth (first brood)			Codling moth (late broods)			Curculio (serious injury)		
					Infestation	Lowest control	Best control	Infestation	Lowest control	Best control	Infestation	Lowest control	Best control
1[1]	435	O. S. W.	Neoga	1913	18.00	78	94				.00		
2[1]	435	O. S. W.	Neoga	1913	18.00	22	89				.00		
3[1]	436	O. S. W.	Neoga	1913	18.00	72	83				.00		
4[2]	437	O. S. W.	Neoga	1913	32.00	78	94	52	62	73	.00		
6	443	O. S. W.	Neoga	1914	14.70	68	100	76	64	97	.00		
7	444	O. S. W.	Neoga	1914	6.00	58	83	51	82	90	.00		
12[3]	454	W. A. R.	Flora	1913	50.10	54	92				.00		
18[4]	461	A. J. G.	Griggsville	1913	2.50	−8	100				67.83	68	85
19	464	A. J. G.	Griggsville	1913	2.50	84	95				67.83	79	91
20	464	A. J. G.	Griggsville	1913	2.50	84	100				67.83	69	94
21	466	A. J. G.	Griggsville	1913	3.66	84	96				57.33	77	85
22	469	A. J. G.	Griggsville	1913	3.66	82	97				57.33	78	89
23	469	A. J. G.	Griggsville	1913	3.66	28	100				57.33	32	60
24	476	A. J. G.	Griggsville	1914	10.25	88	93	21.25	39	74	23.25	71	81
25	476	A. J. G.	Griggsville	1914	10.25	88	98	21.25	39	74	23.25	71	90
26	478	A. J. G.	Griggsville	1914	10.25	46	95	21.25	5	60	23.25	80	97
27	478	A. J. G.	Griggsville	1914	10.25	88	98	21.25	−8	45	23.25	87	96
28	482	A. J. G.	Griggsville	1914	10.25	71	78	21.25	28	40	23.25	80	96
29	482	A. J. G.	Griggsville	1914	10.25	88	93	21.25	47	74	23.25	81	96
30[5]	483	A. J. G.	Griggsville	1914	10.25	90	100				23.25	80	88
31	485	A. J. G.	Griggsville	1914	11.50	76	100	36.50	2	77	33.75	64	91
32	487	A. J. G.	Griggsville	1914	11.50	91	98	36.50	71	82	33.75	87	92
33	487	A. J. G.	Griggsville	1914	11.50	89	91	36.50	55	62	33.75	45	84

[1]Late-brood codling-moth data are omitted from Tables 1, 2, and 3 because no sprays had been applied for the control of an unexpected third brood; in Table 1, however, it is shown that controls running from 21 to 62 percent were obtained; in Table 2, controls of 30 to 52 percent; and in Table 3, controls of 38 to 44 percent.

[2]Late-brood codling-moth data are based on figures for four applications. Jonathan apples were harvested before the appearance of the third brood.

[3]Practically the same data appear also in Tables 14 and 16.

[4]The same data appear also in Table 17.

[5]Late-brood codling-moth data are omitted owing to the fact that no sprays were applied for the control of these insects on plots 14 and 15, while the data for plots 29 and 31 are presented elsewhere. Controls running from 12 to 42 *percent were, however,*

scab amounting in one check plat to 1.41 and in another to 2.33 percent of the crop. Both Bordeaux and lime sulfur, when used separately, completely controlled the disease except in one plat, where lime sulfur exercised a control of 89 percent. The total amount of scab in this plat amounted, however, to only .16 of one percent of the crop, an amount wholly negligible from a practical standpoint. In 1914 no apple scab appeared at Griggsville. Sooty-blotch infections running from 5 to 22.74 percent in 1913 and from 8.5 to 25 percent in 1914 were recorded for the check plats. Both Bordeaux and lime sulfur, however, when used separately, completely controlled this disease in both seasons.

Using Bordeaux and lime sulfur for different applications in the same schedule also gave excellent results in controlling fungous diseases. At Flora in 1913, where there was a serious infection of scab, amounting to 34.9 percent in one check plat and 62.2 percent in another, the combined sprays exercised controls running from 86 to 100 percent. With blotch the results were more variable but of decided importance. The infections in the check plats were 52.6 and 56.6 percent respectively, while the controls varied from 43 to 93 percent. At Griggsville, where there was a slight infection of scab in 1913, the combined sprays resulted in completely controlling the disease, while at the same place from 95 to 100 percent control of sooty blotch was obtained in 1913 and 1914.

Codling moth and curculio, as a rule, were well controlled by applications of arsenate of lead. Table 35 shows that in the entire series of experiments, the control of first-brood codling moth in the most effectively sprayed plats ranged from 78 to 100 percent. In nineteen cases out of twenty-three the control was above 90 percent. Even among the plats least effectively sprayed in each series, controls ranging up to 91 percent were obtained. In a single instance in the Griggsville experiments in 1913 one plat failed to show any control as a result of spraying, but the check-plat infestation was only 2.5 percent, and the difference between the check and the sprayed plat was but a fraction of one percent. Moreover, the most effectively sprayed plat in the same series showed a control of 100 percent.

Later broods of codling moth proved much more difficult to control; nevertheless, in the most effectively sprayed plats, controls ranging from 40 to 97 percent were obtained, while in the least effectively sprayed plats the controls ranged from -8 percent to 82 percent. In only one plat in one series did the sprays show no positive effectiveness in controlling late-brood codling moth.

No data on curculio control were obtained at Neoga or at Flora, but many records were made at Griggsville, where the infestation was sufficiently serious in both 1913 and 1914 to afford excellent opportunity for good comparisons. In 1913 the most effectively sprayed plats

showed controls ranging from 60 to 94 percent and the least effectively sprayed plats from 32 to 79 percent. In 1914 the most effectively sprayed plats showed controls ranging from 81 to 97 percent and the least effectively sprayed plats from 45 to 87 percent. In no case did spraying with arsenate of lead fail to exercise a decidedly beneficial effect.

These results, taken in conjunction with those reported in Bulletin 185, establish even more firmly the advantages of spraying with standard insecticides and fungicides, over no spraying, in controlling some of the more common insects and fungi affecting apples.

2. *What are the relative values of Bordeaux and lime sulfur as sprays for the apple?*

The relative values of Bordeaux and lime sulfur are dependent upon their comparative effectiveness as fungicides and their comparative liability to injure or improve the finish of the fruit and the health and vigor of the tree. In Bulletin 185 it was concluded (page 192) that "Bordeaux and lime sulfur, properly used, are both excellent sprays for the apple." A comparison of the effects of these fungicides in 1913 and 1914 may be obtained from a study of Table 34. It will be seen that, as fungicides, Bordeaux and lime sulfur were equally effective, 100-percent control being obtained in nearly every case.

In their liability to cause injury to the fruit, marked differences between the two sprays appeared. At Griggsville, Bordeaux used alone caused russeting to a greater or less degree on from 50.75 to 92 percent of all the apples to which it was applied. No plats sprayed early in the season escaped the effects of the spray. On the other hand, lime sulfur rarely caused any russeting; its range of injury was from .39 to 7.75 percent. Bordeaux caused no burning of the fruit, while lime sulfur in one case burned 2.5 percent and in another 18.5 percent of the crop. In qualities which contribute to an attractive finish, such as smoothness, high color, and waxy skin, the fruit sprayed with lime sulfur was superior to that sprayed with Bordeaux.

The only data recorded showing a comparison of the effects of Bordeaux and lime sulfur on foliage were obtained at Griggsville. In 1913 the two sprays were equally effective in controlling leaf spot (*Sphæropsis malorum*), the only disease which appeared (page 460); in 1914 the absence of diseases afforded no opportunity for comparison (page 472). In both years the plats sprayed with lime sulfur had more vigorous foliage than those sprayed with Bordeaux (pages 460 and 474).

When all the facts are taken into consideration, it is concluded that both Bordeaux and lime sulfur are efficient fungicides; that neither is always free from injurious effects to the fruit and foliage; that lime sulfur used for sprays before July 1 is less liable to injure fruit and foliage than Bordeaux; that lime sulfur used after July 1,

.y during excessively hot weather, is more liable to injure the fruit than Bordeaux; that lime sulfur used thruout the season is safer than Bordeaux; and, finally, that the most desirable practice is to use lime sulfur for all the applications made in April, May, and, during cool weather, in June, and Bordeaux for applications made in July, or to omit the fungicide entirely from the July sprays, unless the season is very favorable for the development of bitter rot or other fungous diseases.

3. *Are there differences between various brands of arsenate of lead which would make one brand more efficient than another?*

Table 36 presents a summary of the effects of the different brands of arsenate of lead used in 1913 and 1914. Owing to the variation in the number of tests of the different kinds and to the seeming variations in the effects of several of the brands themselves, it is difficult to draw very definite conclusions as to their order of merit. Among the brands that gave rather distinctly inferior results were Grasselli dry, Hemingway paste, and Vreeland dry arsenates of lead. Ansbacher paste arsenate of lead, which was used in one experiment only, gave excellent results in the control of first-brood codling moth and curculio, with a somewhat inferior control of second-brood codling moth. Grasselli, Sherwin-Williams, and Thomsen triplumbic paste arsenates of lead were somewhat inconsistently variable in their effects, giving high degrees of control in some experiments and relatively low in others. The results indicated an average efficiency. In the experiments at Griggsville, Grasselli paste arsenate of lead gave better results than Sherwin-Williams paste arsenate of lead, while in the experiments at Neoga the results were reversed. Corona dry, Dow paste, and Sherwin-Williams dry arsenates of lead gave the most consistently good results of any of the brands used; each of these was tried at Neoga and Griggsville with closely corresponding effects.

4. *Of what value are certain new and proprietary fungicides?*

The new and proprietary sprays tested were copper ferrocyanide, calcium hyposulfite, Thomsen atomic sulfur, Niagara and Grasselli soluble sulfur, and Sherwin-Williams tuber tonic. The effects of these sprays in comparison with the average effects of Bordeaux and lime sulfur are shown in Table 37.

According to these results, the effects of copper ferrocyanide were not unfavorable. The complete absence of fungous diseases in some cases and the presence of only light infections in others, however, prevent drawing definite conclusions regarding the efficiency of the spray.

The fungicidal efficiency of calcium hyposulfite was not determined, owing to the absence of fungous diseases at Neoga, where the spray was used in 1914. It was reported as producing fruit of unusually high color and finish.

TABLE 36.—EFFECTS OF DIFFERENT MAKES OR BRANDS OF ARSENATE OF LEAD USED ALONE AND IN COMBINATION WITH FUNGICIDES ON THE CONTROL OF CODLING MOTH AND CURCULIO, IN FIELD EXPERIMENTS IN SPRAYING, 1913 AND 1914

Make or brand of arsenate of lead	Table	Page	Experimenter	Place	Year	Percentage of—					
						Codling moth (first brood)		Codling moth (late brood)		Curculio	
						Infestation	Control	Infestation	Control	Infestation	Control
Ansbacher paste	31	485	A. J. G.	Griggsville	1914	11.5	98	36.5	59	33.8	90
Corona dry	1[2]	435	O. S. W.	Neoga	1913	18.0	94				
	2[2]	435	O. S. W.	Neoga	1913	18.0	89				
	6	443	O. S. W.	Neoga	1914	14.7	97	76.0	94		
	7[1]	444	O. S. W.	Neoga	1914	6.0	80				
	19[2]	464	A. J. G.	Griggsville	1913	2.5	84 to 92			67.8	79 to 91
	31	485	A. J. G.	Griggsville	1914	11.5	98	36.5	70	33.8	91
Dow paste	6	443	O. S. W.	Neoga	1914	14.7	100	76.0	95		
	7[1]	444	O. S. W.	Neoga	1914	6.0	58				
	31	485	A. J. G.	Griggsville	1914	11.5	85	36.5	53	33.8	71
Grasselli paste	1[2]	435	O. S. W.	Neoga	1913	18.0	83				
	2[2]	435	O. S. W.	Neoga	1913	18.0	72				
	6	443	O. S. W.	Neoga	1914	14.7	73	76.0	84		
	19[2]	464	A. J. G.	Griggsville	1913	2.5	95			67.8	90
	31	485	A. J. G.	Griggsville	1914	11.5	96	36.5	77	33.8	86
Grasselli dry	6	443	O. S. W.	Neoga	1914	14.7	68	76.0	64		
	7[1]	444	O. S. W.	Neoga	1914	6.0	67				
Hemingway paste	2[2]	435	O. S. W.	Neoga	1913	18.0	61				
Sherwin-Williams paste	1[2]	435	O. S. W.	Neoga	1913	18.0	78				
	6	443	O. S. W.	Neoga	1914	14.7	99	76.0	94		
	7[1]	444	O. S. W.	Neoga	1914	6.0	60				
	31	485	A. J. G.	Griggsville	1914	11.5	76	36.5	2	33.8	64
Sherwin-Williams dry	6	443	O. S. W.	Neoga	1914	14.7	97	76.0	92		
	7[1]	444	O. S. W.	Neoga	1914	6.0	58				
	31	485	A. J. G.	Griggsville	1914	11.5	100	36.5	31	33.8	72
Thomsen triplumbic paste	2[2]	435	O. S. W.	Neoga	1913	18.0	72				
	6	443	O. S. W.	Neoga	1914	14.7	97	76.0	92		
	7[1]	444	O. S. W.	Neoga	1914	6.0	83				
	31	485	A. J. G.	Griggsville	1914	11.5	98	36.5	52	33.8	80
	[illegible]	[illegible]	O. S. W.	Neoga	1913	18.0	22				

TABLE 37.—EFFECTS OF CERTAIN NEW AND PROPRIETARY FUNGICIDES, IN FIELD EXPERIMENTS IN SPRAYING, 1913 AND 1914

Table	Page	Experimenter	Place	Year	Fungicide	Percentage of—						Foliage injury
						Scab		Sooty blotch		Russet	Burn	
						Infection	Control	Infection	Control			
4	437	O. S. W.	Neoga	1913	Copper ferrocyanide	.00		.0		.00	.00	None
—	445	O. S. W.	Neoga	1914	Copper ferrocyanide	.00		.0		.00	.00	
21	466	A. J. G.	Griggsville	1913	Copper ferrocyanide	1.41	81	5.0	82	.29	.00	Slight
33	487	A. J. G.	Griggsville	1914	Copper ferrocyanide	.00		8.5	100	0 to 1.0	.00	None
—	445	O. S. W.	Neoga	1914	Sherwin-Williams tuber tonic	Destroyed fruit and foliage						
—	445	O. S. W.	Neoga	1914	Calcium hyposulfite	Fruit highly colored						
—	445	O. S. W.	Neoga	1914	Thomsen atomic sulfur						10.00	
22	469	A. J. G.	Griggsville	1913	Thomsen atomic sulfur	1.41	100	5.0	98	.00	.00	None
32	487	A. J. G.	Griggsville	1914	Thomsen atomic sulfur	.00		8.5	100	.25	4.75	Slight
—	445	O. S. W.	Neoga	1914	Grasselli soluble sulfur	Caused slight foliage injury						
—	445	O. S. W.	Neoga	1914	Niagara soluble sulfur	Caused slight foliage injury						
22	469	A. J. G.	Griggsville	1913	Niagara soluble sulfur	1.41	100	5.0	98	.00	.00	Serious
32	487	A. J. G.	Griggsville	1914	Niagara soluble sulfur	.00		8.5	100	.00	6.25	Serious
Average all experiments					Bordeaux		100		100	79.5	.00	Medium
Average all experiments					Lime sulfur		97		100	2.2	3.00	Slight

Thomsen atomic sulfur compared favorably with Bordeaux and lime sulfur as a fungicide; it generally caused no russet, but produced a somewhat higher percentage of burn than lime sulfur. Its effect on the health and vigor of the foliage was equally satisfactory with lime sulfur.

Niagara soluble sulfur, tho causing only slight foliage injury at Neoga, so seriously injured the foliage in the experiments at Griggsville that its use cannot be recommended. Grasselli soluble sulfur, used at Neoga in 1914, caused slight foliage injury, but no information regarding its value as a fungicide was obtained owing to the absence of fungous infection.

Sherwin-Williams tuber tonic destroyed both fruit and foliage and was clearly worthless as a spray for apples.

5. *Does the method of making copper ferrocyanide affect its efficiency as a fungicide or insecticide?*

Experience in the use of copper ferrocyanide in 1911 and 1912 indicated that its fungicidal properties were not sufficiently effective or active to control the common apple diseases. The composition of the compound, the ease with which it is prepared, and its excellent adhesive properties, however, commend it as a spray. It was decided, therefore, to determine whether different methods of preparation would affect its solubility or its fungicidal properties. This work was performed at Griggsville in 1913, with the results reported in Table 21, page 466, and discussed on pages 467 and 468.

Briefly, the tests included the preparation of copper ferrocyanide by mixing the ingredients, copper sulfate and potassium ferrocyanide, in cold-concentrated, hot-concentrated, and cold-dilute solutions. The very light attacks of fungi rendered comparisons of the fungicidal value of copper ferrocyanide prepared by the several methods insignificant; it is believed that the small differences shown in the results are not to be attributed to the sprays but to unequal infections of the diseases in the plats. As an insecticide, copper ferrocyanide without arsenate of lead prepared by all methods proved worthless.

The extremely insoluble character of copper ferrocyanide has been suggested as an explanation for its ineffectiveness as a fungicide and insecticide. An experiment was performed at Griggsville in 1914 in which acetate of lead was added to the copper ferrocyanide as an accelerating solvent, with the results presented in Table 33, page 487, and discussed on page 488.

Owing to the absence of apple scab, no data were obtained bearing on the control of this disease. The data presented indicated that the spray controlled sooty blotch, but the experimenter states that the freedom of the sprayed plats from sooty blotch may have been due to their location on a slightly higher elevation than the check plats rather than to the effects of the spray. Moreover, the addition of the accelerating solvent failed to increase the insecticidal properties of

the spray to any practical extent. Except where arsenate of lead was added to the spray, the fruit lacked finish and was in no way superior to unsprayed fruit. The foliage was vigorous, but inferior to that on trees where arsenate of lead was also used.

Tho the results presented in Tables 21, 33, and 37 are not sufficiently decisive to warrant a sweeping condemnation of copper ferrocyanide as a fungicide, no matter how prepared, they certainly show nothing that would warrant its recommendation, while as an insecticide it has little or perhaps no value.

6. *What effects have varying quantities, pressures, and nozzle openings on the effectiveness of the sprays?*

Table 38 presents data on the effects of varying quantities, pressures, and nozzle openings on the control of insects and fungi, and on russet and burn. Large quantities refer to drenching sprays; small quantities to thin but complete coatings of spray corresponding rather closely to ordinary commercial spraying. High pressures were from 190 to 250 pounds, low pressures from 100 to 150 pounds. Large nozzle openings were .07 of an inch in diameter, small nozzle openings, .05 of an inch. The large size was, therefore, approximately twice as large as the small one. The openings were of the same size as the large and small openings ordinarily found in commercial nozzles of the disc type.

Large quantities of spray in nearly all cases gave more protection from insects and diseases than small quantities, but caused spray injury on the fruit. In the control of the late broods of codling moth the results are inconsistent and so low in both cases as to indicate that the spray was not applied at the right time. There are indications that moderate amounts applied so carefully as to coat every leaf and apple will satisfactorily control apple scab and sooty blotch, and at the same time prevent serious spray injury, but that large amounts are more satisfactory for the control of first-brood codling moth, curculio, and apple blotch.

High and low pressures varied less in their effects than did large and small quantities of spray. High pressures clearly controlled first-brood codling moth more effectively than low pressures, but the differences were not so great as might have been expected. In the only report on the control of late broods of codling moth, high and low pressures were equally effective. Practically, they were of equal effectiveness, also, in the control of scab and blotch. With regard to spray injury the results must be interpreted with reference to the quantity factor as well as the pressure factor. The table shows that in one case high pressure caused 8 percent serious russet while low pressure caused none; in another experiment high pressure and low pressure caused equally serious injury, and in a third experiment low pressure caused more injury than high pressure. At Neoga there was

TABLE 38.—EFFECTS OF LARGE AND SMALL AMOUNTS OF SPRAY, HIGH AND LOW PRESSURES, AND LARGE AND SMALL NOZZLE OPENINGS, IN FIELD EXPERIMENTS IN SPRAYING, 1913 AND 1914

Treatment	Table	Page	Experimenter	Place	Year	Percentage control—							
						Codling moth (first brood)	Codling moth (late broods)	Curculio (serious)	Apple scab	Sooty blotch	Blotch	Russet (serious)	Burn (serious)
[1]Large amount	13	455	W. A. R.	Flora	1913				97		82	25.40	0
Small amount	13	455	W. A. R.	Flora	1913				90		44	10.60	
[2]Large amount	14	455	W. A. R.	Flora	1913	87			98		86	27.90	0
Small amount	14	455	W. A. R.	Flora	1913	70			94		67	8.80	
[3]Large amount	23	469	A. J. G.	Griggsville	1913	73	7	42	100	100		68.25	
Small amount	23	469	A. J. G.	Griggsville	1913	28	-63	32	100	100		26.00	
[4]Large amount	23	469	A. J. G.	Griggsville	1913	96	49	41	100	100		.66	
Small amount	23	469	A. J. G.	Griggsville	1913	100	47	60	100	100		.25	
[3]Large amount	27	478	A. J. G.	Griggsville	1914	90	-8	96		100		30.25	0
Small amount	27	478	A. J. G.	Griggsville	1914	88	45	87		100		2.00	
[4]Large amount	27	478	A. J. G.	Griggsville	1914	98	18	95		100		.00	12
Small amount	27	478	A. J. G.	Griggsville	1914	92	39	95		100		.00	4
Large amount	28	482	A. J. G.	Griggsville	1914	78	40	96		100		4.75	0
Small amount	28	482	A. J. G.	Griggsville	1914	71	28	80		100		.00	
[5]High pressure	5	438	O. S. W.	Neoga	1913	89	75					8.00	0
Low pressure	5	438	O. S. W.	Neoga	1913	67	75					.00	
[1]High pressure	11	454	W. A. R.	Flora	1913				97		70	20.70	0
Low pressure	11	454	W. A. R.	Flora	1913				93		70	20.20	
[2]High pressure	12	454	W. A. R.	Flora	1913	84			97		80	13.90	0
Low pressure	12	454	W. A. R.	Flora	1913	74			97		78	21.70	
[1]Large nozzle openings	15	456	W. A. R.	Flora	1913				98		75	24.50	0
Small nozzle openings	15	456	W. A. R.	Flora	1913				93		65	17.00	
[2]Large nozzle openings	16	456	W. A. R.	Flora	1913	87			97		84	8.00	0
Small nozzle openings	16	456	W. A. R.	Flora	1913	74			93		77	28.00	

[1]Ben Davis. [2]Jonathan. [3]Bordeaux. [4]Lime sulfur. [5]Intermediate pressures omitted.

quantity check on the pressure experiment; at Griggsville there was no pressure check on the quantity experiment; but at Flora, where the series of experiments was especially planned to investigate this question, corresponding quantity and pressure tests were made. The probable explanation for the above results appears, therefore, in the Flora experiments, where the data showed that spray injury varied with the quantity of spray applied and was not directly attributed to the pressure at which it was applied. Confirmation for this conclusion is found in the results of the quantity experiments at Griggsville, where injury to the fruit varied directly with the quantity of spray applied. The results at Neoga, tho they tend to show that high pressure may be a primary cause for russet, more probably indicate that the quantity of spray rather than the pressure was reponsible for the injury, since, under a higher pressure, the application of a relatively larger quantity of spray occurred. It is to be concluded, therefore, that high pressures can be used safely thruout the entire spraying season provided the quantity of spray applied is properly controlled.

7. *Is it advantageous to interchange Bordeaux and lime sulfur in a spray schedule, using Bordeaux for one or more applications and lime sulfur for the remaining applications?*

Experiments conducted in 1911 and 1912 proved that both lime sulfur and Bordeaux have a place in the spray schedule and indicated that while lime sulfur should be used for the two sprays following the fall of the petals in May or the first part of June, Bordeaux should be used in hot weather during the latter part of June and the remainder of the summer. The effects of Bordeaux and lime sulfur for the cluster-bud spray left room for doubt, some experiments indicating that lime sulfur was as effective as Bordeaux, and others showing less favorable results.[1]

Information bearing on this question was obtained in 1913 and 1914, both from direct experiments made at Griggsville and from results obtained in other experiments where the spray schedule happened to permit comparisons. The direct experiments are recorded in Table 18, page 461, and in Table 25, page 476. These results confirm the desirability of using lime sulfur for the two applications following the fall of the petals, and Bordeaux for July sprays, and in addition they indicate that lime sulfur is more satisfactory for the cluster-bud spray than Bordeaux, since it gave equally good control of fungous diseases and caused no russeting of the fruit. Thruout all the experiments burn occurred only where lime sulfur was used during July, and then in hot weather. Russeting invariably followed the use of Bordeaux for the cluster-bud spray in the experiments at Flora and at Griggsville, but was not always observed in the experiments at

[1] J. C. Blair et al., Ill. Agr. Exp. Sta. Bul. 185, pp. 193-194.

Neoga. In occasional instances russeting resulted from the use of lime sulfur applied after the fall of the petals (Table 34, page 491), but in these cases the amount was small and generally the plats sprayed with lime sulfur alone were entirely free from this form of injury.

It is definitely concluded from these experiments, therefore, that when fungicides are required, lime sulfur should be used for all the early applications, including the cluster-bud spray, the calyx spray, and other sprays applied in May, or during cool weather in June, and that Bordeaux should be used during hot weather in June and at all times later in the summer.

8. *What are the effects of certain special spray practices on the control of codling moth?*

Experiments on the problem of special sprays included the application of drenching sprays and of several applications made in addition to the regular sprays. Drenching sprays were applied in order to observe their efficacy in controlling first-brood codling moth. The other special sprays were applied in order to test their efficacy in controlling late broods of codling moth.

TABLE 39.—EFFECTS OF DRENCHING SPRAYS ON THE CONTROL OF FIRST-BROOD CODLING MOTH, IN FIELD EXPERIMENTS IN SPRAYING, 1913 AND 1914

Table	Page	Experimenter	Place	Year	Treatment	Percentage control of first-brood codling moth
8	446	O. S. W.	Neoga	1914	Drenching spray (Bordeaux nozzle)	98
					Ordinary spray (Average of disc nozzles)	72
23	469	A. J. G.	Griggsville	1913	Drenching spray (Average of heavy applications)	84
					Ordinary spray (Average of light applications)	64
26	478	A. J. G.	Griggsville	1914	Drenching spray (Bordeaux nozzles)	46
					Ordinary spray (Disc nozzles)	95
27	478	A. J. G.	Griggsville	1914	Drenching spray (Average heavy application)	94
					Ordinary spray (Average light application)	90

Table 39 presents the data obtained where drenching sprays were used. In three cases out of four the drenching spray was more effi-

serious in controlling first-brood codling moth than the ordinary spray, but in the fourth case it was less than half as efficient. The experimenter in charge explains, however, that as this spray was applied with a hand outfit and thru Bordeaux nozzles, it was impossible to keep up a satisfactory pressure, and that consequently the spray failed to reach the calyx cups so well as the other sprays. In the other three experiments the sprays were applied either with a power outfit or thru disc nozzles under satisfactory pressures. It is concluded, therefore, that a rather large amount driven home under considerable pressure is desirable for the calyx spray.

TABLE 40.—EFFECTS OF SPRAYING FOR LATE BROODS OF CODLING MOTH, IN FIELD EXPERIMENTS IN SPRAYING, 1913 AND 1914

Table	Page	Experimenter	Place	Year	Time of application	Percentage control of late broods of codling moth
4	437	O. S. W.	Neoga	1913	July 8–10	17
9	447	O. S. W.	Neoga	1914	July 8–10	0
30	483	A. J. G.	Griggsville	1914	July 8–10	58
9	447	O. S. W.	Neoga	1914	June 14	54
9	447	O. S. W.	Neoga	1914	Sept. 1	42
9	447	O. S. W.	Neoga	1914	June 14, July 8, Sept. 1	91

Table 40 presents the results of sprays applied especially for the control of late broods of codling moth and forms the basis for one of the most important conclusions derived from the experiments performed in 1913 and 1914. The spray applied July 8 to 10 is the regular second-brood codling-moth spray. The sprays made at Neoga in 1914 on June 14 and September 1 were applied because of the prevalence of adult moths and eggs then in the orchard and because of the failure of the early July spray to control the late broods in 1913. The results show that the regular second-brood codling-moth spray was largely ineffective at Neoga in 1913 and entirely so in 1914, while a spray applied about the middle of June reduced late-brood injury by 54 percent, a spray applied September 1 reduced it 42 percent, and sprays applied both the middle of June and on September 1 reduced it 91 percent. At the same time at Griggsville the early July spray reduced injury from late broods of codling moth by 58 percent.

In connection with these data must also be considered the facts that in both 1913 and 1914 a third or partial third brood of codling moth appeared very late in the summer, and that the weather conditions appeared to be very favorable for a rapid reproduction and development of the insect.

It is concluded, therefore, from these experiments in which codling-moth attacks varied in time and severity with the season and

locality that (1) in exceptional seasons, a fixed schedule is likely to fail in effective control; and (2) it is possible, by expert observation, to determine the proper time and the probable need for sprays for late broods of codling moth.

9. *Can lime sulfur be diluted sufficiently to prevent burn in hot weather and at the same time retain its fungicidal effectiveness?*

Table 29, page 482, presents the results of an experiment performed at Griggsville in 1914 to answer this question. The results show almost equal amounts of burn where weak and strong solutions were used, together with equal control of sooty blotch, the only disease recorded. These results, however, are not to be considered conclusive, because of the general absence of fungous diseases and also because of the fact that the greatest dilution used was only 1 in 50.

Incidental Observations

1. At Neoga in 1914 the trees in the sprayed plats were banded with paper or burlap bands designed to act as traps for pupating codling moths. In confirmation of the favorable results which many times in the past have been claimed for this practice, trap-banding was found to be a useful supplement to spraying in controlling codling moth, especially when the pests are numerous.

2. A fixed spray schedule is based on the proposition that spraying is an insurance to be employed annually against certain frequently recurring insects and fungi whose habits are presumably fairly constant and well known. A fixed spray schedule has the advantage of simplicity and can be learned and followed easily by the majority of fruit growers. Experience has shown its practicability and widely satisfactory results. The results of the spraying experiments in 1913 and 1914, however, raise the question of the advisability of adhering to a rigid spray schedule.

A complete and final answer to the question cannot be derived from the results of the experiments in 1913 and 1914 nor from the combined results of all the spraying experiments performed thus far by this and other experiment stations. From the information now available the conclusion appears warranted that a fixed spray schedule must be the backbone of spraying advice, but that variations from this schedule may be determined by painstaking observations made either by growers whose skill, training, judgment, available time, and knowledge of the theory and practice of orchard spraying fit them to observe and interpret their observations correctly, or by their scientifically trained representatives working in the field and laboratory.

Recommendations

The following recommendations, while largely similar to those presented in Bulletin 185, present certain modifications based on the results of the work in 1913 and 1914, including recommendations regarding pressures; a change from Bordeaux to lime sulfur for the cluster-bud spray; the omission of the application within ten days after the calyx spray except in previously neglected orchards and in seasons favorable for apple scab development; the application of a spray commencing three weeks after the calyx spray, approximately just preceding the hatching of the first-brood codling-moth eggs; and the addition of a special apple-blotch spray six to seven weeks after the fall of the petals in localities where blotch is prevalent.

1. *Dormant-tree Spray.*—This spray is used particularly for the control of San Jose scale. It is applied in the fall after the leaves have dropped or in the spring before the buds have opened, preferably at the latter time. Where San Jose scale is present or is known to infest a certain locality, this spray is a necessity, and it is advised as a matter of precaution in all orchards thruout the state.

The dormant-tree spray should be either commercial or homemade lime sulfur. The commercial lime sulfur testing 33° Baumé should be used at the rate of 11 gallons of commercial lime sulfur to 89 gallons of water, or 11 gallons of commercial lime sulfur in 100 gallons of the spray. This is equivalent to 1 gallon of commercial lime sulfur to 8 gallons water. The homemade lime sulfur, made according to the Illinois formula (100 pounds sulfur, 50 pounds lime, 66 gallons water), is used at the rate of 20 gallons of stock solution homemade lime sulfur to 80 gallons of water, or 20 gallons of homemade lime sulfur in 100 gallons of spray.

The dormant-tree spray may be applied at as high a pressure as the machine in use will permit, preferably 175 pounds or more. Satisfactory work, however, can be done at low pressures if pains are taken to spray thoroly.

2. *First Regular Summer Spray (Cluster-bud Spray).*—This spray is used particularly for the control of apple scab. A secondary object in its use, however, is to kill the various leaf-eating insects which appear early in the season, including bud moth, tent caterpillar, and cankerworm. These insects, tho not always present in large numbers, are likely to cause serious damage and hence must be guarded against. Thruout the southern third of the state this spray may be omitted in orchards which are free from cankerworm, and which were free from serious scab infection during the preceding season.

The first summer application is made after the cluster buds open, as soon as the individual flower buds spread apart, but before the

flower buds themselves open. In large commercial orchards it will be found necessary to begin spraying before all the individual flower buds have spread apart, in order to complete spraying before the first blossoms open. Spraying may be continued at this time until the petals have commenced to separate, but should be discontinued as soon as the stamens and pistils of the flowers are exposed.

Lime sulfur at the rate of 2½ gallons of commercial concentrated, or 5 gallons of homemade (Illinois formula) solution in 100 gallons of spray, with 4 pounds paste or 2 pounds dry arsenate of lead, should be used at this application.

This spray may be applied with satisfactory results at all pressures from 100 to 250 pounds. Care must be taken, however, to spray thoroly at the low pressures and to avoid excessive spraying at the high pressures.

3. *Second Regular Summer Spray (Calyx Spray).*—This spray is used particularly for the control of codling moth, but it is of almost equal importance as a preventive of apple scab. Incidentally, it is advantageous as a protection against curculio and various leaf-eating insects.

It is applied immediately after the fall of the petals, while the lobes of the calyx are still distended. The greater number of the first-brood codling moth enter the apple thru the calyx end. By spraying the trees while the calyx cups are still open, poison will be placed on the bases of the lobes and stamens and sometimes within the cup itself, where the larvæ of the codling moth are reasonably sure to get it when entering the apple. At this stage the small apples point upward or outward, and the calyxes are easily coated with poison.

For this application lime sulfur arsenate of lead, at the rate of 2½ gallons of commercial concentrated lime sulfur or 5 gallons of homemade lime sulfur (Illinois formula) with 4 pounds paste or 2 pounds dry arsenate of lead in 100 gallons of spray, should be used. This spray is most effective applied at high pressures, but will give good results at all pressures from 100 to 250 pounds. Very thoro work, even at the risk of wasting some material, is advised.

4. *Extra Apple-scab Spray.*—This spray, designed to control apple scab, is necessary in neglected orchards, and is desirable in well-cared-for orchards in cool, showery seasons favorable for the development of apple scab. It should be applied within ten days after the second summer application, or calyx spray. Incidentally it may be helpful in controlling codling moth, leaf-eating insects, and such fungous diseases as blotch, sooty blotch, and leaf spot. These latter, however, are better controlled by the third regular summer spray, which should be applied three weeks after the second, or calyx spray. In the northern part of the state, where the extra apple scab spray is made, the regular third summer spray may be omitted. In the southern

part of the state, however, it is necessary to retain the regular third spray as a protection against apple blotch.

For this application lime sulfur arsenate of lead, 2½ gallons of commercial concentrated lime sulfur or 5 gallons homemade lime sulfur (Illinois formula) with 4 pounds paste or 2 pounds dry arsenate of lead in 100 gallons of spray, should be used. This spray will give good results at all pressures from 100 to 250 pounds.

5. *Third Regular Summer Spray (Hatching Spray, First-brood Codling Moth; First Apple-blotch Spray.)*—This spray is designed to supplement the calyx spray in destroying first-brood codling moth. It renews the coating of poison on the exterior of the apple where rapid growth and rains may have thinned it out or removed it, thus insuring a poisoned meal both on the skin of the apple and within the calyx cup when the newly hatched codling moth begins to feed. Usually the application should be made three weeks after the calyx spray in the southern part of the state, and four weeks after the calyx spray in the northern part of the state, but accurate observations of the time of the appearance of the moths and the laying of the eggs may permit an exact determination of the proper time for this spray. This application is the most important one for the control of apple blotch, is often useful in apple-scab control, and incidentally furnishes protection against leaf-eating insects, curculio, sooty blotch, and leaf spot.

For this application lime sulfur arsenate of lead, 2½ gallons of commercial concentrated or 5 gallons homemade lime sulfur (Illinois formula) with 4 pounds paste or 2 pounds dry arsenate of lead in 100 gallons of spray, should be used. This spray will give good results at all pressures from 100 to 250 pounds.

6. *Second Apple-blotch Spray.*—This spray is necessary only in orchards where blotch is prevalent. It should be applied two to three weeks after the third regular summer spray.

Lime sulfur, 2½ gallons of commercial concentrated or 5 gallons homemade lime sulfur (Illinois formula) in 100 gallons of spray, should be used unless the weather is unusually hot (90° F. or above), in which case Bordeaux (8-8-100) should be substituted. Arsenate of lead is usually unnecessary in this spray, but if observations indicate the free hatching of codling-moth larvæ at this time, the poison should be added in the usual proportions.

7. *First Bitter-rot Spray.*—This spray is necessary only in the southern third of the state and in orchards where bitter rot is known to be prevalent. Its application may even be confined, in individual orchards, to localized areas or to susceptible varieties. The time for application is July 1.

Bordeaux (8-8-100) should be used. Pressures from 100 to 250 pounds will give satisfactory results.

8. *Fourth Regular Summer Spray (Second-brood Codling-moth Spray).*—This spray is applied particularly for the control of second-brood codling moth. Incidentally it is useful for the prevention of curculio-feeding injury, and, in case a fungicide is added, for blotch, sooty blotch, and leaf spot.

It is made approximately ten weeks after the bloom, or at times varying from July 1 in the extreme southern part of the state to August 1 in the northern part of the state. Exact observations on the time of general emergence of second-brood moths and their period of egg-laying, however, will permit an accurate determination of the time for this spray.

Unless fungous infection is anticipated, 4 pounds of paste or 2 pounds of dry arsenate of lead and 4 pounds of freshly slaked lime in 100 gallons of water should be the spray used. If a fungicide is desired, Bordeaux (8-8-100) should be used. This spray may be satisfactorily applied at all pressures ranging from 100 to 250 pounds.

9. *Extra Bitter-rot Sprays.*—Where bitter rot is anticipated, it is necessary to spray four times at intervals of ten days, commencing July 1. One of these applications, generally the second, will coincide with the regular second-brood codling-moth spray. Following this application, therefore, there should be two extra bitter-rot applications at ten-day intervals.

Bordeaux (8-8-100) should be used at pressures which may vary from 100 to 250 pounds.

10. *Extra Codling-moth Spray for Third Brood.*—Somewhat rarely the apple crop in the southern half of Illinois is very seriously damaged by a third brood of codling-moth larvæ. In such seasons a spray should be applied for their control. The time for the application ought to be determined by careful observations of the appearance of the third brood of adult moths and their period of egg-laying. Such an attack would probably occur between the last week in August and the close of the harvest season. The attack is not likely to come all at once, but will probably be more or less continuous. August 28 to September 3 proved to be the correct time for this spray in the experiments at Neoga in 1914. Observations made at Griggsville during the same season indicated that the second or third week in September would have been the correct time in that locality.

For this spray use 4 pounds paste or 2 pounds dry arsenate of lead and 4 pounds freshly slaked lime in 100 gallons of water. Apply under pressures ranging from 100 to 250 pounds.

INDEX

Amounts of spray, varying, 455, 499-501
Apple flea-weevil, 452, 453
Apple leaf roller, 452, 453
Applications: dormant, 431; summer, 431; times of, 431
Banding trees, for codling moth, 447, 504
Bitter rot, sprays for, 507, 508
Blotch, 452, 454-57, 493, 499
 Sprays for, 506-07
Brown spots on foliage, 460, 468, 470, 474, 475
Bud moth, spray for, 505
Burn, lime sulfur, 429, 445, 448, 474-75, 480-86, 489, 494-98, 501, 504
Cankerworm, spray for, 505
Codling moth, 429, 432-40, 441, 443-48, 454-57, 463-71, 472-89, 490-93, 495-99, 502-04. Sprays for, 506-08
Cracking, 437-38
Curculio, 460-71, 474-88, 490, 493-97, 499. Sprays for, 506-07
Fourth summer application, value of, 481-84. *See* also Sprays, special
Frog-eye fungus, *see* Leaf spot
Leaf burning, 434, 445, 484
Leaf burning (tip and edge), 465, 468, 470, 474, 475, 479, 481, 486
Leaf spot, 452, 453, 460, 463, 467, 468, 470, 494. Spray for, 506
Nozzles
 Effectiveness of various types, 445-46
 Size of, varying, 456-57, 499-501
Objects of 1913-1914 experiments, 429
Orchards, location and description
 Flora, 1913, 451
 Griggsville, 1913, 458
 Griggsville, 1914, 472
 Nroga, 1913, 432
 Nroga, 1914, 441
Pressure, varying, 437-39, 445, 454-55, 499-501
Recommendations, 505-08
Records, 431
Russet, Bordeaux, 429, 432, 437-38, 440, 445, 449, 454-57, 460-65, 470-71, 474, 477-84, 486, 489, 494, 499-502
Russet, lime sulfur, 435, 460, 467-70, 474, 480
San Jose scale, spray for, 505
Scab on foliage, 452, 453, 472
Scab on fruit, 454-57, 460-71, 488, 490-93, 498-99. Sprays for, 505-07
Sooty blotch, 460-71, 474-89, 493, 498
 Sprays for, 506-07
Spray schedule
 Fixed, 504
 Recommended, 505-08.
Sprays
 Acetate of lead, with copper ferrocyanide, 488
 Arsenate of lead
 Brands of, 434-36, 442-45, 484-86, 495. Ansbacher, 486, 495; Corona, 435, 443-44, 486, 495; Dow, 443-44, 486, 495; Grasselli, 435, 443-44, 486, 495; Hemingway, 435, 495; Sherwin-Williams, 435, 443-44, 486, 495; Thomsen, 435, 443-44, 486, 495; Vreeland, 435, 495; used alone, 434-35, 443-44; with lime sulfur, 435-36, 444-45
 Effectiveness of, 490-94
 Formula, 431
 Paste and powdered, compared, 465
 Atomic sulfur, 445, 468, 486, 498
 Bordeaux
 Compared with lime sulfur, *see* Lime sulfur and Bordeaux
 Effectiveness of, 490-94
 Formula, 430
 Russet, description and cause, 449
 Calcium hyposulfite, 445, 495
 Copper ferrocyanide, 445, 495
 Prepared in different ways, 467-68, 498-99
 With acetate of lead, 488
 With arsenate of lead, 437
 Lime sulfur
 Commercial (formula), 430
 Compared with atomic sulfur and soluble sulfur, 468, 486
 Effectiveness of, 490-94
 Homemade (formula), 430
 Various strengths of, 467, 481, 504
 Lime sulfur and Bordeaux
 Interchanging, value of, 463, 475-77, 501-02
 Light and heavy applications, 470, 479-81
 Relative values of, 459-60, 473-75, 494-95
 Soluble sulfur, 445, 468, 486, 498
 Special, for codling moth, 502-04
 Drenching, 477-79, 502
 For delayed broods, 446-47, 503
 Fourth summer, for second brood, 436-37
 Standard
 Formulas and preparation, 430-31
 General effectiveness of, 490-94
 Tuber tonic, 445, 498
Tent caterpillar, spray for, 505
Yellow-leaf, 438, 474, 475, 479, 486